SCIENCE ABSTRACTS.

Section A.—PHYSICS.

OCTOBER 1921.

GENERAL PHYSICS.

1645. *Apparatus for Approximate Harmonic Analysis and for Periodicity Measurements.* **W. L. Balls.** (Roy. Soc., Proc. 99. pp. 283–292, July 1, 1921. Engineering, 112. p. 469, Sept. 30, 1921.)—A description is given of a simple apparatus by which periodicities can be determined, harmonic analysis effected, and curves smoothed. The results obtained are only approximately correct, but the errors involved need not exceed 3 %. The chief advantage of the apparatus is the speed with which it can be used; *e.g.*, some 50 trial periods can be examined in less time than is required for the computation of a single trial period by the periodogram arithmetical method. A. W.

1646. *Hatchet Planimeter.* **J. Satterly.** (Roy. Astron. Soc. Canada, J. 15. pp. 221–243, July-Aug., 1921.)—A description is given of the hatchet planimeter, and the theory of the instrument is also developed. It is shown that for rough work the instrument gives good results, and its simplicity and cheapness, combined with the fair accuracy obtained, render it very suitable for laboratory use. About 50 are in constant use in the Physics Laboratory of Toronto University. A. W.

1647. *New Harmonic Analyser.* **W. Mason.** (Am. J. Sci. 1. pp. 484–490, June, 1921.)—The instrument described consists of an L-shaped piece of wood or metal, grooved on the bottom to allow a xylonite curve to slip into place when the framework is placed over it. Lugs then keep the curve in place. A series of transparent xylonite pieces, one for each sine or cosine harmonic, on which particular curves have been engraved, are the instrument curves referred to. An arm carrying a xylonite strip with a straight line engraved on it, is fastened to the framework by a pivot O; at the end of this arm is a small hole in which a pencil point, or the tracing point of a planimeter may be placed. The essential operation consists in tracing the wave-form to be analysed with the intersection of the arm and the instrument curve, and at the same time drawing the derived area by means of a pencil point, or measuring the area of the derived curve direct. It is stated that the method gives an accuracy equal to that of any other analyser except the Henri. A. W.

1648. *A Recording Torsion Balance.* **W. Schweydar.** (Zeits. Instrumentenk. 41. pp. 175–183, June, 1921.)—This balance is of the type introduced by Eötvös. An iridio-platinum wire, 0·04 mm. diam., 56 cm. long, carries a beam 40 cm. long of aluminium tube. At one end of the beam is a gold mass of 30 gm., and suspended from the other end is an equal copper mass. Surrounding this system, whose vibration period is 24 minutes, is a three-fold case, the object of which is to screen the suspension from temperature variation. The apparatus is pivoted on a base, and by clockwork can be rotated on this. At regulated times a glow-lamp is lighted, whose rays, reflected into the case and to the beam mirror, return to a photographic plate and are there recorded. The position of the beam relative to the case in general varies from one azimuth to another, since the horizontal gravitational field is not in general uniform. This variation in the horizontal field depends on the density of strata near the balance. By this means the character of the strata on the earth's crust can be investigated. The most simple form of expression used is $\phi = m_2 Lh/\tau \,.\, dg/ds$, where ϕ is the displacement of the beam from normal due to the strata, $m_2 = 30$ gm., L = half-length of beam, τ = modulus of torsion of the fibre, dg/ds is the gradient of the field in a horizontal direction, and h the vertical distance between the suspended masses m_2.

The value of ϕ is shown by observation of two bright spots on the photographic plate, one from a mirror on the beam, and another from one on the surrounding case.

To ascertain the horizontal field completely several pairs of azimuths must be investigated, the components of each pair being 180° apart.

P. E. S.

1649. *Direct-Reading Tachymeter.* (Zeits. f. Instrumentenk. 41. pp. 189–190, June, 1921.)—Describes an instrument by Kern and Co. (Switzerland), in which the horizontal distance and difference of level between the instrument position and the staff position are obtained by direct reading from the curves on two sector plates attached to the telescope.

J. W. T. W.

1650. *New Correction Scale for Mercurial Barometers.* **S. P. Ferguson.** (Monthly Weather Rev. 49. pp. 289–293, May, 1921.)—E. Gold [Roy. Meteorol. Soc., J., July, 1914] has devised a scale for use with the "attached" thermometer, such that the reading gives directly the correction to be applied to the observed pressure to obtain the true station-level pressure, thus embodying the corrections for index error, latitude, and temperature. This scale is only accurate at one given pressure, and the author has carried out a simple extension of it, to cover any range of pressure. With ordinary station barometers the correction can be read off to 0·01 millibar. There is a simple adjustment to allow for any constant change of correction, such as would be produced by moving the instrument to a different latitude.

Dividing Machine for Fan-shaped Scales.—The scale can be made with any ordinary dividing engine, but as the rulings are not parallel, but spread out in fan shape, the graduation is more readily performed by a special *dividing machine* described in the article. A number of advantages are claimed for the employment of such a scale, in particular that it reduces the number of operations involved in other methods, where tables are used, that the corrections can be read more accurately, and that time and space are saved in recording.

M. A. G.

1651. *Sharpness of Points for Ruling on Glass.* **A. Mallock.** (Nature, 108. pp. 10–11, Sept. 1, 1921.)—The author finds that in ruling test-plates for microscope objectives certain aniline colours dried on glass are preferable to silver, as their opacity is very intense, and their adherence to glass is greater than their intrinsic strength. He finds that steel points may be obtained with a sharpness which appears perfect under a microscopic power of 300, but it is necessary to use extremely small pressures in grinding. He concludes that it might be just possible to rule lines separated by 1/100,000 in. with a steel point if very great care were exercised in bringing the point into contact with the film at the beginning of each line. The load on the point should not be greater than 1/200 grain. The microscopic examination of a number of natural (vegetable) points showed that in no case were these as sharp as that of the ordinary needle. J. W. T. W.

1652. *Moduli of Rigidity for Spruce.* **H. Carrington.** (Phil. Mag. 41. pp. 848–860, June, 1921.)—Describes a series of determinations of the moduli for prisms of rectangular cross-section, 12 in. long, and longest side up to 1½ in. The effective radius of the torsion couple was 2 in. An optical method was used to determine the angles of twist. The specimens used were in every case cut from portions of wood over 12 in. from the pith, and with the annual layers either parallel to opposite sides, or to the ends. It was found that values obtained from pieces nearly adjacent to each other in the balk often varied considerably.

J. W. T. W.

1653. *Compressibility Measurements on Solid Bodies.* **E. Madelung** and **R. Fuchs.** (Ann. d. Physik, 65. 4. pp. 289–309, June 28, 1921.)—Recent developments of the crystal lattice theory have necessitated further measurements of the compressibility of crystals having a simple chemical constitution. Previous measurements, which in many cases require verification, are given in tables taken from the papers of Regnault and Amagat for metals, Röntgen and Schneider for rock salt and sylvine, Voigt for characteristic representatives of the crystal systems, Richards and his pupils for numerous elements and the haloids of Na, K, Ag, and Th, and Grüneisen for metals [see Abs. 440 (1911)]. The experimental methods employed may be classified in two groups: (1) Piezometric; (2) determination from elastic constants. In the present investigation the piezometric method was considered with all the variations as used by Voigt, and a new apparatus designed, which is described in detail and illustrated by several diagrams. The compressibilities and densities of 57 mostly simple minerals are communicated, these including 40 new determinations. H. H. Ho.

1654. *Contact Pressures and Stresses.* **E. G. Coker, K. C. Chakko,** and **M. S. Ahmed.** (Inst. Mech. Eng., J. No. 5. pp. 365–433; Disc., 434–467, July, 1921. Engineering, 111. pp. 373–376, March 25; 387–389, April 1; 439–440, April 8, and pp. 471–473, April 15, 1921.—Abstract.)—An examination is made of the stresses set up in a body loaded over a very limited portion of its surface; the examination is partly mathematical and partly carried out by means of polarised light, the specimens being made of cellulose. (1) *Contact pressures due to line sources.*—It is shown mathematically that the distribution of stress, due to a line source, normal to a semi-infinite plane, is purely radial, and that the lines of principal stress consist of circles round a point of application, intersected by straight lines passing through the origin. Practically such a condition is not realised, due to the impossibility of obtaining true line contact and to the introduction of other forces by the supporting system; experiment shows that the pressure is not uniform. (2) *Stresses in blocks loaded over part of one edge, and supported over the opposite edge.*—Measurements were made on a square block, 1 in. side and $\frac{1}{8}$ in. thick, loaded over the central part of one of its rectangular faces, the load being applied by a pressure plate $\frac{1}{8}$ in. wide and, in a second experiment, $\frac{1}{4}$ in. wide. Tables and diagrams are given showing the lines of principal stress and the iso-clinic lines. (3) *Stresses in blocks loaded over the whole of the upper and lower surfaces.*—In the case of a short rectangular block, loaded over the whole of its upper and lower surfaces by means of thick distributing plates, it is sometimes assumed that the block is uniformly stressed throughout, but this is not usually the case, for if the materials pressed together are of a different nature, the stress distribution is non-uniform. The pressure between dissimilar materials apparently gives rise to considerable tangential stress at the common boundary, and lateral expansion is prevented. If, however, a very extensible material is interposed, the tangential stress is reversed and the lateral strains become abnormally great, especially near the central vertical section. The experimental evidence goes to show that in order to obtain pure compression stress in a block, the contact surfaces must be similar and equal, and of the same material. (4) *Influence of contact stresses in testing materials.*—It is well known that in testing metals, the bars often fracture at the gauge-points, especially in hard metals. This is a case of contact stresses of practical importance, and an apparatus was made to study the stresses in a celluloid model gripped by a device made to imitate the action of point or line grips. It is shown that the lateral loads due to screw-points gripping the specimens not only cause injury and often determine the place of fracture, but they may also change the stress distribution. The inherent difficulty of determining the true strength of a material under a tension test, when it is necessary to make an indentation or scratch, has led Dalby to abandon the ordinary methods of attaching the extensometer. In his arrangement the specimen is turned from a solid bar with collars spaced a convenient distance apart, and the extension is measured by suitable mechanism bearing lightly against the collars. Tests were made on a model, in celluloid, of a section through the Dalby test-piece, and it was found that, in the neighbourhood of the flanges there is a local, though small, increase of stress. J. L. H.

1655. *Comparative Tests of Steels at High Temperatures.* **R. S. MacPherran.** (Chem. and Met. Eng. 24. pp. 1153–1155, June 29, 1921. Paper read before the Am. Soc. for Testing Materials, June, 1921.)—The methods employed in carrying out the tensile tests are described in detail and the apparatus for electrical heating and temperature control illustrated diagrammatically. Curves showing variation of yield-point, max. tensile strength, elongation, and reduction of area with temperatures ranging from atmospheric to between 1000° and 1300° F. are given for various rolled open-hearth steels, forged Ni steels, forged Cr-Ni steel, rolled high Cr-high Ni steel, forged Cr-Va steel, forged high Cr steel, forged high Mn steel, and forged high C-Cr-Va steels, with chemical analysis in each case. It is shown that there is no one temperature at which all steels will show a decided change in physical properties. The max. tensile strength usually occurs at a higher temperature than the minimum ductility. The majority of the tensile strength curves drop sharply above 800° F. The effect of Ni in small amounts is slight, but in large percentages it tends to lower the temperature at which the tensile strength declines. Only steels containing Ni show material diminution of ductility at the higher temperatures. The results indicate that the introduction of metals forming carbides tends to strengthen steels at high temperatures. A. B. C. L.

1656. *A Consequence of the Laws of Friction.* **É. Delassus.** (Comptes Rendus, 172. pp. 1335–1337, May 30, 1921.)—A problem is considered in which one solid commences to move upon another, and which leads to an equation of the fourth degree between x, y and F, x and y being two axes in the tangent plane and F the force of friction. There are four roots to this equation, but only a positive root will correspond to the actual friction. There is a special case, where there are three positive roots which are equal to one another, and a small circle drawn round this point in the xy plane is divided by a curve into two portions, in one of which there is one positive and three negative roots and in the other three positive and one negative. In the first portion, of course, the positive root gives the value of the friction, and at first sight it seems easy to determine which of the three positive roots in the second portion does the same, by proceeding step by step from a point in the first portion to a point in the second, along the circumference of the circle, and following the root F, step by step from the position where it certainly represents the forces of friction to the position where there are three positive roots. It would seem that this decides which of these three roots represents the force of friction, but it appears that if we proceed in the opposite direction round the circle we arrive at one of the other positive roots. This proves that the mathematical theory is incapable of representing the phenomenon under consideration even approximately.

It is found that this peculiarity exists not only if the simple formula $F = fN$ is adopted for connecting the force of friction with the force normal to the tangent plane, but also with the formula $F = \phi(v) + Nf(v)$, v being the sliding velocity, so that all such laws have to be rejected. The trouble is probably in our fundamental ideas with regard to the nature of friction, and experiments which are being made appear to indicate that these fundamental ideas are really inaccurate, though so far the results have to be regarded as qualitative rather than quantitative. H. N. A.

1657. *Triple Pendulums with Mutual Interaction and the Analogous Electrical Circuits.* II. **E. H. Barton** and **H. M. Browning.** (Phil. Mag. 42. pp. 17–34, July, 1921.)—The present work was carried out with a slightly simpler arrangement of three interconnected pendulums than that used for the first paper. The arrangement here used is subjected to analysis which shows that the pendulums execute resultant vibrations each compounded of two or three simple vibrations. Two of these component vibrations have frequencies which are derivable from the lengths in use, as in the case of simple pendulums. The third component vibration has a frequency which is a function of the three lengths concerned. Certain general relations between the amplitudes and phases of the components are also derived; these take special values for various initial conditions. A comparison between this mechanical case and the triple electrical system to which it is analogous reveals a strong general resemblance, but with slight variations in detail. Thirty-six photographic records are given, each showing triple traces, and on careful examination these are seen to give a satisfactory confirmation of the theory. E. H. B.

1658. *Vibration of a Sphere in a Vibrating Fluid.* **M. Wagenschein.** (Ann. d. Physik, 65. 5. pp. 461–480, July 14, 1921. Dissertation, Giessen.)—Describes experiments made to test the correctness of the formula given by W. König [see Abs. 1054 (1916)] for the relation between the amplitude of a vibrating fluid, the amplitude of a sphere otherwise unacted upon by forces, the size and density of the sphere, the viscosity of the fluid, and the period of vibration. The experiments were made in a swinging vessel the contents of which vibrated as a whole, and the spheres used were (*a*) lycopodium powder in air, (*b*) large spheres of various materials in water, and (*c*) air bubbles in glycerine. The agreement with the theoretical values is satisfactory except in the case of very viscous materials, where it is possible that the walls may exert an effect on the motion of the fluid. J. W. T. W.

1659. *Vibrations of a Crystalline Medium.* **H. Hilton.** (Phil. Mag. 42. pp. 148–156, July, 1921.)—Various assumptions which have been made about the nature of the intermolecular forces of a crystal are discussed. The treatment is mainly mathematical and cannot be usefully abstracted. A. B. C. L.

1660. *The Stability Problem in Hydrodynamics.* II. **C. W. Oseen.** (Ark. f. Mat., Astron. och Fysik, Stockholm, 14. No. 16. pp. 1–53, 1920.)—The previous communication by this author [Abs. 292 (1912)] contained a synopsis of the work done on this subject. The standpoint then arrived at was that in order to explain the transformation from regular laminar motion to the irregular and turbulent which had been observed in the flow of water through a cylindrical tube, Osborne Reynolds assumed that the laminar motion given by hydrodynamic theory for this case becomes labile at a particular average velocity. From dimensional considerations he evolved the expression, $\rho \, . \, dU/\mu = S$, for this critical velocity, where ρ is the density of the liquid, μ the viscosity coefficient, d the inner diameter of the tube, U the average velocity, and S is a constant. The present author dealt in 1911 with a special case of the problem, and showed in the two-dimensional case that a given disturbance did not produce any new state of motion but only one superposed on the laminar motion. This he extended to the three-dimensional case. From his results the conclusion was drawn that the stability problem must be attacked from an entirely different standpoint, and that the influence of unevenness at the walls and the quadratic terms of the hydrodynamic differential equations must be considered. The following conclusions of Mises are quoted: The laminar motion between absolutely smooth walls is always stable. The actual fluid motion, however, takes place under other conditions. The disturbances to laminar motion happen continually in consequence of the molecular unevenness of the walls. The problem to be investigated is when a continuous disturbance at the boundary spreads out over the whole interior. Rayleigh is quoted as saying that "there can remain little doubt that the shearing motion is stable for infinitesimal disturbances. It has not yet been proved theoretically that the stability can fail for finite disturbances on the supposition of prefectly smooth walls, but such failure seems probable." Noether's work is described at some length, following which comes a reference to Reynolds' experiments, whereby two different critical velocities are distinguished. The subsequent work by Morrow, Barnes, and Coker on the distribution of velocity in a viscous fluid over the cross-section of a pipe and on the action at the critical velocity is then considered.

The present paper contains an investigation of the influence exerted by permanent disturbing forces or unevenness of the walls upon the laminar flow between two planes. In order to get simple and decisive results the work has been confined almost exclusively to the limiting case of vanishing friction (viscosity), and the influence exerted by disturbing conditions under very small viscosity. The problem is dealt with in three stages, namely: (1) The influence of impressed forces upon a limitless fluid whose motion corresponds to $u = \beta y$, $v = 0$; (2) the influence of the same forces on planes parallel to the x-axis in the fluid; (3) the influence of unevenness in the walls. The treatment is limited to the two-dimensional problem. The paper is mathematical throughout.

H. H. Ho.

1661. *Figure of Isolated Rotating Drop of Weightless Liquid.* **J. Boussinesq.** (Comptes Rendus, 172. pp. 941–946, April 18, and pp. 1085–1086, May 2, 1921.)—The problem is of some theoretical interest in that theologians of the thirteenth century attempted to account for the sphericity of the earth by the analogy of drops of rain or dew. They therefore appear to have admitted, implicitly at any rate, its original fluidity, as was done explicitly, 500 years later, by Newton and his successors, taking account of weight; the author, of an initial rotation and the attainment of a permanent figure. In a meridian plane of the drop take a and b, the equatorial and polar semiaxes as x and y axes respectively. Take the density as unity, then the pressure p, due entirely to the constant surface tension f, on the internal face of the surface layer, assumed a surface of revolution, is known to be the product of $2f$ by the mean curvature of this layer, which latter is known to be $d\left\{xy'/(1 + y'^2)\right\}/2x dx$, for all points x, y, of the half meridian on the positive side of x. Then it is shown that, where ω is the angular velocity, r the radius of curvature of the meridian at the pole, $\omega(r^3/8f)^{1/2} \equiv k$, and $u \equiv x^2/r^2$, the equation of the meridian will be $y = b - r/2 \int [o, u](1 + k^2 u)du / \left\{1 - u(1 + k^2 u)^2\right\}^{1/2}$. An approximate solution, assuming that k^4 and higher powers may be neglected, gives the relation $(a - b)/a = 1{\cdot}06117k^2$. If R be the radius of the drop when at rest, and therefore spherical, the exact relation $(R/r)^3 = (1 - b/r)/2k^2$. Combining this with the approximate result above, it is found that $r = 0{\cdot}99R$.

G. W. de T.

1662. *Radial Strain in a Gravitating Sphere.* **J. Ghosh.** (Calcutta Math. Soc., Bull. 12. pp. 11–14, June, 1921.)—In Love's "Elasticity" (second edition), p. 140, it is stated that, when a homogeneous elastic sphere is strained by the mutual gravitation of its parts, there exists within the sphere a spherical surface over which the displacement is zero. On one side of this surface the material is compressed and on the other side it is in tension. The present paper shows that the same applies in the following cases: (1) A homogeneous sphere with a concentric spherical hollow, or a nucleus with a density different from the rest of the sphere. (2) A heterogeneous sphere, the density varying as some positive integral power of its distance from the centre. The sphere may be either complete or hollow, the latter case giving an exception when the density varies as the first power of the distance from the centre. H. N. A.

1663. *Some Consequences of the Lorentz Contraction from the Point of View of Cohesion, Gravitation, and Electromagnetism.* **F. Guéry.** (Comptes Rendus, 172. pp. 1094–1097, May 2, 1921.)—The general considerations of the Lorentz contraction are discussed. From the conclusion that matter may be considered as composed of elementary particles occupying only an extremely small portion of space it is argued that, in respect of cohesion, to establish an exact scale of deformation, a coefficient less than unity may be applied to the effect of cohesion on the elementary particles of bodies in motion with respect to the ether. The hypothesis has been favourably regarded that the force of cohesion would vary with the fifth power of the inverse of the distance. Taking k as the factor of the Lorentz contraction, in applying the above considerations to the equations of motion of a material particle under the action of this force, the coefficient in question has a value k^6. Similar considerations are applied and developed mathematically for gravitation as exemplified in the sun and Mercury, and for electromagnetism as exemplified in the case of an electric charge displaced in a straight line with uniform velocity with respect to another charge supposed fixed. A. B. C. L.

1664. *Ether, Light, and Matter.* **O. Lodge.** (Phil. Mag. 41. pp. 940–943, June, 1921.)—Some time ago McLaren published a paper in which, among other things, he attempted to explain gravity by treating matter as a source or sink of ether. The flow of ether which is thus necessarily postulated is supposed to transfer momentum from the destroyed portion to the boundary of its destruction, and thus virtually to exert a stress on the surface of transition, notwithstanding that matter is unlike a foreign body immersed in a stream, but is a peculiarity of the ether itself. McLaren thought objections would be raised to locomotion of the ether, as perturbing to the rays of light; but so long as motion is irrotational it can be shown that rays of light are unaffected, though the waves are carried along and made eccentric. A short proof of this is given. Hence a flow of ether need not be objected to on the ground of a perceptible disturbance to rays of light; but a variety of reasons for objecting to the idea of locomotion of the ether may be given, one of the most important being that the only motion permissible in a universal medium of infinite extent is a circulatory or vortex motion, such as might occur along lines of magnetic force. A. W.

1665. *Internal* (*Self*) *Diffusion in Solid Lead.* **J. Gróh** and **G. v. Hevesy.** (Ann. d. Physik, 65. 3. pp. 216–222, June 14, 1921.)—In a previous communication [see Abs. 7 (1921)] the authors have shown briefly that the velocity of spontaneous diffusion, *i.e.*, the velocity with which the atoms (molecules) of fused lead change their places, can be ascertained by measuring the velocity with which a radio-active lead isotope diffuses in fused lead. The present paper contains an experimental account of the attempted determination of the self-diffusion velocity in solid lead. The extraordinarily great resistance which change of position in the solid state should encounter, points to an extremely slow rate of self-diffusion, so that the investigation has been made with the metal heated to within 46 deg. C. of its fusion point. Several series of experiments, of duration from 1 to 3 months, showed that this self-diffusion for lead at 280° C. was less than 0·001 cm.² per day. An experimental series was performed in which lead threads of about 2 cm. in length were kept warm for over 400 days. These threads consisted of 1½ cm. of inactive and ½ cm. of active lead. From these long-period experiments no diffusion of the active lead isotopes in the inactive lead was established. The diffusion constant of the solid lead was accordingly even less than 0·0001 cm.² per day, a magnitude which should have been evaluated by the experimental means employed. This result is compared with the Roberts-Austen data for the diffusion of gold in solid lead, which at 251° is at least 300 times faster than that of lead in lead at 280°. Other examples are given for the diffusions of different metals and the essential difference between this phenomenon and that of self-diffusion is pointed out, a difference also true for the fused metal, where the self-diffusion constant for liquid lead differs only slightly from that of gold into lead. Polonium was also employed simultaneously with the lead isotope radium D, without, however, a positive result being attained. Experimental details are included.

Conductivity of KNO_3–$NaNO_3$ Mixtures.—A comparison is made with the conductivities of KNO_3 and $NaNO_3$. An equimolecular mixture of KNO_3 and $NaNO_3$ at 220° C. conducts 360–460 times better than pure solid KNO_3 or $NaNO_3$; while at 670° an equimolecular mixture of KCl and NaCl conducts 200 times better than the pure salts. These considerable differences in conductivity are essentially due to the resistance changes encountered in the ionic migrations. A connection is sought for between these results and the metallic phenomena. H. H. Ho.

1666. *Dimensions of Atoms.* **A. O. Rankine.** (Phil. Mag. 40. pp. 516–519, Oct., 1920.)—The author reproduces in the accompanying table estimates by W. L. Bragg [Abs. 21 (1920)] of the sizes of the domains occupied in crystals by the atoms of the inert gases, side by side for comparison with the values in column 4 calculated from the author's measurements of the viscosities recorded in previous papers [A. O. Rankine, 959 (1911). 635 (1915)], and representing the distances of nearest approach, the Sutherland correction having been applied, together with the similar figures for Cl, Br, and I, calculated in accordance with Langmuir's theory making the dimensions of molecules of chlorine, bromine, and iodine, respectively, practically equal in dimensions to pairs of atoms of argon, krypton, and xenon, and on the assumption that it is justifiable to treat such molecules as colliding with the same frequency as they would, were they spheres of the same volume and mass. In order to facilitate comparison the increments of diameter in passing from one element to the next have been placed in columns 3 and 5. All the dimensions are given in Ångström units (Å. = 10^{-8} cm.). The molecule of O and N are, according to the indications of the kinetic theory, of approximately the same dimensions, and approximate calculations on the basis of similar assumptions indicate that molecules of both resemble dimensionally two atoms of neon in contact. This agrees with Bragg's measurements, and affords additional justification for his assumption that the diameter of the outer electron shell of neon is practically identical with those of the incomplete outer shells of O and N.

Element.	From Crystal Measurements.		From Viscosity Measurements.	
	Atomic Diameter.	Increment.	Atomic Diameter.	Increment.
Neon	1·30		2·02	
		0·75		0·54
Argon	2·05		2·56	
		0·30		0·20
Krypton	2·35		2·76	
		0·35		0·30
Xenon	2·70		3·06	
Chlorine	2·10		2·34	
		0·28		0·17
Bromine	2·38		2·71	
		0·42		0·27
Iodine	2·80		2·94	

With regard to these figures, it should be borne in mind that whereas those in the second column represent the actual diam. of the outer electron shell, those in the fourth cannot be regarded as such. It is quite improbable that even in a direct collision between thermally agitated atoms, the approach is so close that the electrons of the atoms intermingle. The mean distance between atomic centres during collisions may therefore be expected to be in excess of the diam. of the outer electron shell of each participating atom. The above figures support this view, all the numbers in col. 4 being in excess of the corresponding numbers in col. 2, although the order of magnitude is the same. Moreover, although there is no evidence of strict proportionality, there is general accordance between the increments of diameter in passing from one electron shell to the next. G. W. DE T.

1667. *Dimensions of Atoms.* **A. O. Rankine.**—(Roy. Soc., Proc. 98. pp. 360–369, Feb. 2, 1921.)—The author here re-examines the conclusions arrived at in an earlier paper [see preceding Abs.] in the light of S. Chapman's work [Abs. 794 (1916)] substituting Chapman's formula for one previously employed, and which he considers is definitely superseded by it, with the result of obtaining substantial quantitative in place of merely qualitative agreement with W. L. Bragg's results. From the close agreement between the values of the atomic radius according to Chapman's formula, and those obtained from van der Waals' law, he considers it beyond doubt that the atoms of monatomic gases in thermal agitation behave like mutually attracting hard spheres, the absolute diameters of which are now practically known to three significant figures. Assuming with Bragg that his values measure the diameters of the outer electron shells, it appears that not even the *outer* electrons intermingle in an encounter, so that, as far as collision is concerned, the atom must be considered as a hard elastic sphere of radius, σ, definitely greater than the distance d between the centre and the outer electrons. The ratios obtained for d/σ are found to depend on the type of atom. Chapman's viscosity formula, as all such, gives the means of calculating, not σ directly, but $\pi\sigma^2$ the area presented as a target to other atoms. Following the Lewis-Langmuir theory, he constructs hypothetically from the diatomic gases three alternative types of molecule formed by two overlapping spheres, and finds that the max. deviations from unity in the ratio of the area so obtained to that calculated by Chapman's formula and the best available viscosity does not exceed 6 %. For one of these models, a spheroid of major axis $2(d + \sigma)$ and volume $8\pi\sigma^3/3$, the deviations do not exceed 3 %. The author therefore considers himself justified in claiming that :—(*a*) There is substantial quantitative consistency between the estimates of atomic dimensions deduced from X-ray crystal measurement and from the kinetic gas theory. (*b*) In size and shape the atoms of the monatomic inert elements are nearly indistinguishable from the atoms, respectively, of the neighbouring diatomic elements in the periodic table. (*c*) The Lewis-Langmuir theory accounts satisfactorily for the kinetic behaviour of the molecules of O, Cl, Br, I in relation to that of the corresponding inert atoms, Ne, A, Kr, X. In the case of N, the Lewis-Langmuir theory receives negative confirmation in that, whatever be the actual arrangement of the N-molecule, its mode of formation from two atoms is essentially different from that of its neighbour, the O-molecule. G. W. DE T.

1668. *Stability of the Rutherford Atom.* **J. Marshall.** (Roy. Soc. Edinburgh, Proc. 40. Pt. 2. pp. 150–157, 1919–1920.)—The author's analyis shows that if the law of force between a positive nucleus and negative electron be of the form $(1 - b^{n-2}/r^{n-2})r^2$, a value can be found for n which will preserve the stability of a group of electrons, not exceeding seven, revolving in a circular orbit round a positive nucleus. Since b is smaller than the atomic radius, for distances large relatively thereto, this law will differ negligibly from that of the inverse square, giving stability for the simple cases of the Rutherford atom. For a series of electron rings, the solution is shown to hold on the tentative assumption that, so far as the effect of an inner set of rings on the outer set is concerned, the inner set may be replaced by an equivalent charge at the centre of the atom. For more than seven electrons in the outer ring, the electron displacements perpendicular to the plane of the orbit will be unstable. This seems to indicate the possibility of the atom being built up of a series of rings of seven electrons, which would suggest periodicity in the chemical properties of atoms corresponding to Mendeléeff's classification, stated by Newlands in 1864 in the form, "the eighth element starting from a given element is a kind of repetition of the first." G. W. DE T.

1669. *Atomic Structure.* **N. R. Campbell.** (Nature, 107. p. 170, April 7, 1921.)—A short note in further explanation of an earlier communication [see Abs. 209 (1921)]. The author refers to N. Bohr's remarks and discusses the "fixed" and "orbital" electron types of atomic structure. A. B. W.

1670. *Atomic Nuclei.* **E. Gehrcke.** (Phys. Zeits. 22. pp. 150–152, March 22, 1921.)—On the basis of the work of Aston, Rutherford, and the author, diagrammatic representations of the nuclear structures of the following elements are given:—N, C, O, Ne (20 and 22), Cl (35, 36, 37, 38, and 39). A. B. W.

1671. *Positive-Ray Analysis of Magnesium.* **A. J. Dempster.** (Nat. Acad. Sci., Proc. 7. pp. 45–50, Feb., 1921.)—The author has previously described an apparatus [Abs. 788 (1918)] for positive-ray analysis and gave examples of hydrogen, oxygen, sodium, and potassium rays, showing that at least the lighter elements could be readily analysed so as to separate any molecules differing in molecular weight by unity. The experiments have recently been resumed and an account is now given of experiments with magnesium. Three components are found, of weights 24, 25, and 26 in the relative proportions 6 : 1 : 1 respectively. This gives an average atomic weight 24·375 which is in good agreement with the accepted atomic weight for magnesium. A. B. W.

1672. *Structure of the Atom and Radio-Active Phenomena.* **H. Geiger.** (Zeits. Elektrochem. 26. pp. 274–277, July 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1920.)—The electrons surrounding the Rutherford nucleus protect the nucleus against attack by other atoms unless the latter approaches with high velocities (α-particles). The scattering then taking place has been investigated by the author and Marsden; it does not give information about the structure of the nucleus. Radio-active phenomena show that the nucleus must itself have a complex structure. The nuclei seems to contain rotating or oscillating systems which become unstable under certain conditions; the higher the velocity at which α-particles are emitted, the shorter the life of the respective substances. H. B.

1673. *Structure of the Atomic Nucleus.* **W. Lenz.** (Zeits. Elektrochem. 26. pp. 277–281, July 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1920.)—In the inverted Bohr model of the author and of Stern and Vollmer a stationary electron occupies the centre of the hydrogen atom, and hydrogen nuclei rotate round this centre. According to the quantum relation the radius of this inverted model should only be 1/2000 of the radius of the Bohr atom. For helium the nucleus should then be of the order of a few 10^{-12} cm. whilst other estimates yield 2×10^{-13}. The discrepancy may be due to the inapplicability of Coulomb's law to nuclear dimensions. On Einstein's suggestion Swinne [Abs. 1076 (1913)] attempted to apply the principle of relativity (all energy W has inertia W/c^2) to radio-active processes in the uranium series; the attempt failed, because our knowledge of the atomic weights is too uncertain. When we accept the relativity principle, however, the mass of the nucleus must be smaller than the sum of the masses of the separated constituents, and Prout's hypothesis loses its basis. We meet with the same difficulty when we attempt to apply energy calculations to Rutherford's experiments on the splitting up of nitrogen by bombardment with α-particles. *A priori* we are not able to say whether splitting up should occur, even if there be an excess of energy, since we do not understand the mechanism of the decomposition. Yet we should expect decomposition when the difference between the mass of the products and that of the regional nucleus is smaller than W_a, the kinetic energy of the α-particle. This condition seems to hold for nitrogen; but again we cannot sufficiently rely upon our atomic weights, and products of unknown atomic weights might be formed. Yet Rutherford's failure to split helium nuclei off carbon and some other atoms need not necessarily imply that none have been formed. The author does not accept the cogency of Lindemann's objection [Abs. 1684 (1915)] to the rule of Geiger and Nuttall as to the relation between the life and the range of radio-active substances [see preceding abstract]; according to Lindemann, the explosion of an atom would require the fortuitous coincidence of about 80 independent events. According to Rutherford β-rays are not emitted at distinct velocity-steps, and the β-spectrum of RaC does not originate directly in the nucleus, but owes its existence to secondary photoelectric processes. With regard to these β- and γ-spectra the author refers to Eucken's rotation spectra [see Abs. 1621 (1921)]. H. B.

1674. *Ionisation Potential and the Size of the Atom.* **A. S. Eve.** (Nature, 107. pp. 552–553, June 30, 1921.)—Hughes in his book on "Photo-Electricity" (p. 51) indicates that the work in removing an electron wholly from an atom might be expected to vary inversely as the radius; in other words, the ionising potential might be inversely proportional to the cube-root of the atomic volume. W. L. Bragg [Abs. 21 (1921)] has given the diameters of atoms in Å.U. (10^{-8} cm.) on the assumption of close packing in crystal structure.

The author now makes a comparison of the ionisation potentials—(1) with the diameters as given by W. L. Bragg, and (2) with the cube-root of the atomic volume. The tabulated values given in the paper indicate: (1) In the first group of the periodic table, the work done in the removal of an exterior electron is nearly inversely proportional to the radius. (2) The same remark as in (1) applies to the first 4 elements of the second group, while the members of the sub-group B diverge considerably from the values for the A group. (3) In the case of the inert gases, neon and argon, the diameters estimated by Bragg give better agreement than those found from the cube-root of the atomic volume. (4) The values for certain elements in groups iii–vii are given in the table for comparison, but definite conclusions are not possible owing to the uncertain state of our knowledge of ionising potentials. A. B. W.

1675. *Atomic Radius and Ionisation Potential.* **M. N. Saha.** (Nature, 107. pp. 682–683, July 28, 1921.)—The author deduces from Bohr's atomic model that the atomic radius varies inversely as the ionisation potential, as indicated in an earlier paper by A. S. Eve [see preceding Abs.]. A table of comparison is given showing the atomic radii calculated from crystal data (Bragg) or from the kinetic theory of gases (Rankine and others). A. B. W.

1676. *Constitution of Nickel; Mass Spectra.* **F. W. Aston.** (Nature, 107. p. 520, June 23, 1921.)—Reference is made to the author's analysis of nickel positive rays by means of the mass-spectrograph. The vapour of nickel carbonyl (mixed with CO_2) was used in the analysis, the ordinary discharge tube being employed to produce the positive rays. The spectrum was found to consist of two lines, the stronger at 58 and the weaker at 60. The results were checked by comparison with the mercury and CO_2 lines and an accuracy of 0·1 % attained. Nickel, therefore, consists of two isotopes, of ratio 2 : 1 in intensity, being therefore consistent with the accepted value 58·68 for the atomic weight of nickel. A. B. W.

1677. *Asymmetry of Gas Molecules. A Contribution to the Determination of Molecular Form.* **R. Gans.** (Ann. d. Physik, 65. 2. pp. 97–123, May 31, 1921.)—The present paper on the form of gas molecules succeeds the author's previous work on the geometric form of ultramicroscopic particles determined by means of their absorption curves and also by analysis of their emitted light [see Abs. 1232 (1920)]. Gas molecules have an advantage over colloidal particles in that they are all with certainty congruent and sub-ultramicroscopic, so that the author's theory is here directly applicable. In the theoretical part, the meaning of the term "shape of gas molecule" is discussed at length. At the commencement of the present work only the first of Strutt's papers on the Tyndall-effect in gases was available, and his observations were repeated since parallel light had not been used. The numerical results obtained, however, deviated only slightly from those of Strutt. Section 2 of the paper contains a detailed account of the final experimental arrangements; and Section 3, of the measurements of the filter transparency in which Strutt's procedure was adopted. In Section 4 the results are assembled for carbon dioxide, oxygen, nitrogen, ammonia, and nitrous oxide. Section 5 discusses the shape of the molecules, and Section 6 the asymmetry of the molecule and the Kerr-effect. In the latter section the double refraction of a gas in the electric field is shown to be determined by the orientation of the molecules in consequence of the electrostatic forces. Section 7 discusses the molecular shape according to the Clausius-Mossotti theory. Section 8 deals with the shape of the particle and the magnetic rotation of the plane of polarisation. Since the depolarisation of the Tyndall light and the Kerr phenomenon in gases can only be explained by the asymmetry of the molecules, a magnetic rotation of the plane of polarisation will similarly be produced by an isotropic union of particles capable of oscillation. The author now investigates how far the constants derived from the depolarisation experiments can quantitatively explain the Faraday-effect. The Verdet constants appear to offer a satisfactory confirmation of the observations made. A diagram is included, showing meridian sections of the gas molecules of helium, carbon dioxide, ammonia, and carbon disulphide, constructed on the Clausius-Mossotti theory. [The paper teems with experimental data.] H. H. Ho.

1678. *Isotopes.* (Roy. Soc., Proc. 99. pp. 87–104, May 2, 1921.—Discussion.)—**J. J. Thomson.**—Refers to the conception of isotopes on the electron theory of the atom and its bearing on the chemical and physical properties of isotopes. Detailed consideration is then given to the most dramatic case of chlorine, especial consideration here being given to the work of F. W. Aston. The experimental results of the latter are criticised. In the first place, if chlorine is an invariable mixture of its "isotopes" (which cannot be separated chemically), then it is to be expected that under all circumstances the ratio of the intensities of the positive-ray "lines" should be invariable. Earlier observations of the speaker, however, indicated that this was far from being the case.

Another question raised has regard to the accuracy of Aston's measurements—the speaker doubting if an accuracy of 1 in 1000 is yet possible. A suggestion is made that a possible error of 1 in 1000 might creep into the deflection experiment, where the pencil of positive rays passes through magnetic and electrostatic fields. The speaker concludes with the following remark: "I believe there is no branch of science where promise of great discoveries is more helpful than those which will result by researches which involve the application of physical principles and physical measurements to chemical phenomena."

F. W. Aston.—Commences by explaining how it is possible to show that the lines due to "chlorine" are indications of real isotopes, and not to possible combinations of chlorine and hydrogen. He considers the photographic method as dangerous for a numerical comparison of line intensities: electrical methods are best. The speaker corrects a mistake of J. J. Thomson's regarding the accuracy of the positive-ray analysis. He explains how an accuracy of 1 in 1000 is easily attainable. Slides showing the spectra of chlorine, lithium, krypton, argon, xenon, iodine, and other elements were exhibited.

F. Soddy.—Confines his remarks to the early history of isotopes, which had its origin in the study of radio-active change. In 1910 it was recognised that elements identical in chemical character existed, and in 1913 the speaker designated such elements "isotopes" (signifying "the same place") to express their nature in the light of the new interpretation of the periodic law. Reference is made, in conclusion, to the use of isotopes as chemical "indicators" by Paneth and v. Hevesy.

T. R. Merton.—Refers to his work on the spectroscopic identification of isotopes and the determination of differences in their atomic weights.

F. A. Lindemann.—Differs in regard to a statement that "isotopes have identical chemical properties," and shows mathematically that two substances of different atomic weight must be separable chemically in principle. He states that it is highly probable that isotopes of diatomic molecules, such as Cl_2, should have different spectra. It is also suggested that isotopes might be separated electrolytically if, as seems likely, they have different migration velocities in solution. A. B. W.

1679. *Electronic Structure of Heavy Atoms.* **L. de Broglie** and **A. Dauvillier.** (Comptes Rendus, 172. pp. 1650–1653, June 27, 1921.)—The paper aims at a comparison of the physico-chemical indications concerning the electronic structure of the elements with those furnished by a study of their X-ray spectra. One of the authors has previously proposed a periodic classification of the elements based on their electronic structure, this classification being now reproduced. The authors now extend the classification to the elements He, Ne, A, Kr, X, Em, Ur. One of the authors has recently determined the number and the magnitude of the sources of energy in the uranium atom by a study of the spectra of the L-series of that element, finding only 5 distinct electronic layers, K, L, M, N, O, with a possible 6th, P, layer.

The bearing of these observations is now discussed in relation to Lilienfeld's work, and to Eddington's theory of the equilibrium of stars.

A. B. W.

1680. *Probable Normal State of the Helium Atom.* **E. C. Kemble.** (Phil. Mag. 42. pp. 123–133, July, 1921.)—Several suggestions have been made regarding the orbits of the electrons in the normal helium atom. Bohr's model, consisting of two electrons revolving about a common circular orbit, is the simplest, but gives the wrong ionisation potential. The Landé model [Abs. 807 (1920)], which identifies the normal atom with the stationary state corresponding to the one-quantum sharp series coplanar-orbit term (1, *s*), must be discarded for the same reason. The author has recently applied the Sommerfeld quantum conditions to the Langmuir model, which consists of two electrons that oscillate in symmetrical arcs on opposite sides of the nucleus, and has shown that if these quantum conditions are correct, this model also has the wrong energy. Again, the model of the normal helium atom proposed by Franck and Reiche [Abs. 1492 (1920)] cannot be correct, for it gives no explanation of the chemical properties of helium, it gives the wrong ionisation potential, and does not harmonise with the observations of Fricke and Lyman on the ultra-violet emission spectrum of helium [Abs. 1436 (1921)].

The experimental facts regarding the excitation of the various lines in the arc spectrum of helium, show that the only stationary states from which direct passage to the normal state is ordinarily possible are those of the series (*m*, S) (Sommerfeld's notation); that the direct transfer of atoms from the states (*m*, S) to the normal takes place with relative difficulty; and that the presence of some impurity in helium provides an indirect path for the return of atoms to the normal state which is accompanied by the emission of more than one radiation frequency.

The application of the Bohr principle of selection to the passage of atoms from the stationary states of higher energy to the normal state, if legitimate, leads to the conclusion that the resultant angular momentum of the normal He atom is zero. Neither of the two possible models having zero angular momentum is satisfactory, and it seems probable that the application of the Bohr principle of selection to atoms returning to the normal state will have to be abandoned. A symmetrical model with one unit of angular momentum, similar in many respects to that of Franck and Reiche, is suggested as a possible solution of the problem. [See also Abs. 1279 (1920).] A. W.

1681. *Valency Forces in the Building-up of Crystals.* **H. Thirring.** (Zeits. Elektrochem. 26. pp. 281–286, July 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1920.)—According to Kossel the valency forces are not like tentacles, but are the electrostatic forces of the ions which occupy points of the crystal lattice. On this view we are unable to understand how the ions are kept apart; thermal movement would, in the Bragg model of NaCl, approach certain point-charges to one another, and the whole, so far symmetrical, structure should collapse. There must be also repulsive forces, and the author finds these in the electronic movements after Born and Landé. The paper is a critical review of this theory, which admits of calculating some thermochemical quantities, but is so far restricted to heteropolar compounds and practically to the halides of the alkali metals. H. B.

1682. *Viscosity and Molecular Dimensions of Gaseous Cyanogen.* **A. O. Rankine.** (Roy. Soc., Proc. 99. pp. 331–336, July 1, 1921.)—In the theory of molecular structure of Lewis and Langmuir [Abs. 991 (1919)] the CN radical is supposed to be practically identical in the arrangement of its outer electrons with the N_2 molecule, except that it lacks one electron. The junction of two CN radicals is conceived to be brought about by the sharing of one pair of outer electrons. The validity of this view can be tested on the basis of the author's theory with reference to collisions between non-spherical gaseous molecules, provided that the molecular dimensions of N_2 and C_2N_2 deduced from viscosity measurements are known. The object of the present paper is the provision of the viscosity measurements of C_2N_2, those for N_2 being already available. The apparatus and method of employment are briefly described. The ratio of the viscosities of C_2N_2 and air at 15° C. is determined, and a comparison is made of the viscosities of C_2N_2 at 15° C. and 100° C. From these results the absolute data for C_2N_2 are deduced. Sutherland's law is assumed to hold, and, by means of a modification of Chapman's formula, the molecular dimensions are calculated. The results are discussed in relation to the views of Lewis and Langmuir. A. B. C. L.

1683. *X-ray Structure of Potassium Cyanide.* **P. A. Cooper.** (Nature, 107. pp. 745–746, Aug. 11, 1921.)—Reference is made to the investigations by A. O. Rankine [see preceding Abs.] of the structure of the CN molecule, as deduced from the viscosity and molecular dimensions of gaseous CN, and the present work was undertaken with a view to throwing further light on the subject by means of the X-ray examination (*a*) of small single crystals of KCN by the ordinary spectrometer method; (*b*) of powdered crystals by the modified method of W. H. Bragg. The readings obtained are given and indicate that the underlying structure of KCN is similar to that of KBr. The data obtained, while sufficient to fix the position of the CN radical as a whole with respect to the K atom, give practically no evidence as to the disposition of the C and N atoms towards each other. A. B. C. L.

1684. *The Cohesion Force in the Diamond.* **A. Landé.** (Zeits. f. Physik, 4. 3. pp. 410–423, 1921.)—The subject matter of the paper is based on the assumption that cohesion in homopolar as in heteropolar crystals depends on the electrostatic attractions and repulsions between the stationary atomic nuclei and the moving electrons. The effect of homogeneous atoms upon each other, whose inner motions are executed with equal periods, is dependent upon the orbital differences of the electronic movements. If in a crystal the phases of the separate atoms are distributed according to probability, then the average force between two atoms over a period will change by chance from place to place, and no regular crystal lattice can arise, but only a structure of changing molecular distances with irregularly distributed density which undergoes slow fluctuations in consequence of the phase alterations gradually taking place. The regular structure of monatomic crystals compels the conclusion that all particles are ordered in the phases of their electronic motions. In the simplest case, all like atoms must possess the same phase, or, otherwise expressed :—At every instant, not only the atomic nucleus, but also the corresponding electrons of all like atoms form a lattice, which oscillates about the stationary lattice of the atomic nuclei. By means of this lattice synchronism, the regular structure of crystals is guaranteed, as also a cohesion force in homopolar crystals. For the carbon atom, it is shown that in the free state the real volume is deformed in a definite manner by the neighbouring atoms.

Section 2 deals with the spacial symmetry of separate carbon atoms. Section 3 demonstrates that with the carbon atom, as with the Na^+ ion and F' ion, the 8 electrons execute diquantic elliptic orbits, as also the 4 external electrons, apart from disturbances. In Section 4 the compressibility of the diamond is calculated from the empirical data of the heat of sublimation and the molecular volume, with the provisional assumption that the lattice potential is determined by two terms of a power series according to the lattice dimensions, viz. an attraction and a repulsion. Physically the result of the calculation signifies that the diamond consists of positively and negatively charged cube ions. Since, however, the homopolar nature of the diamond is regarded as certain, the conclusion is drawn that the determination of the potential by only 2 series expressions does not correspond with reality, and that the lattice potential is determined by the interaction of a larger number of approximately equally great series terms, or, otherwise expressed :—That the carbon atoms in the diamond are so arranged that the disturbances to the electronic orbits can only be calculated by badly converging series. [The paper is mathematical throughout.] **H. H. Ho.**

1685. *The Bohr Atom. Circumnuclear Lagrange Function.* **M. Brillouin.** (Comptes Rendus, **173.** pp. **30–32, July 4, 1921.**)—The author has worked out the most general Lagrange function, which will give special orbits with the essential characters required by Bohr and Sommerfeld. This function L is equal to $L_0 + L_\mu + L_\nu$, where L_2 is the function given by classic mechanics and electrostatics, and L_μ and L_ν are two functions in which Planck's constant h is introduced. The two resulting equations of motion contain the sines and cosines of μ and ν, which are the two *actions* of the problem. The special orbits are given by $\sin \mu = 0$, $\sin \nu = 0$. The quanta equations, which assign special values to the constants (eccentricity, major axis) of the Kepler orbits, are $\mu = n\pi$, $\nu = n'\pi$. The special orbits are of two kinds, according as n and n' are odd or even, or as the cosines are $+1$ or -1. This change of sign of the cosines affects the stability of the orbits. The arbitrary coefficients in the equations of motion can be chosen so that the even values of n and n' give stable orbits, and the odd values unstable orbits, with whatever degree of stability or instability may be required by the problem. The author has studied the properties of a heterogeneous medium producing the actions which are described by the new Lagrange function, and which would represent in a more complete manner the emissive properties of the atom. **H. N. A.**

1686. *Critical Study of the Capillary-Rise Method of Determining Surface Tension, with Data for Water, Benzene, Toluene, Chloroform, Carbon Tetrachloride, Ether, and Dimethylaniline.* II. **T. W. Richards** and **E. K. Carver.** (Am. Chem. Soc., J. **43.** pp. **827–847, May, 1921.**) —The paper commences by a consideration of the contact angle. One of the moot points concerning the validity of results with the capillary-rise method of determining surface tension is the question as to whether or not the meniscus of the liquid surface is exactly tangent to the inner wall of the capillary tube at its highest point. Various attempts to settle it have been made with varying results [see Abs. 1372 (1915)], and the consensus of opinion seems to be that in most cases the angle of contact is zero. More convincing evidence, however, is needed. The present method consists in the direct observation of the angles of reflection of rays of light from the region immediately surrounding the line of union of the liquid and glass. It has been shown that the supposed finite contact-angle (reputed to be the weakest point in the capillary-rise method), does not exist with the liquids studied if the glass be properly cleaned, and if evaporation of the liquid be prevented. The correction calculated by Rayleigh and Laplace for the capillary rise in the wide tube has been experimentally verified. A preliminary experimental curve of the capillary rise in tubes that are not wide enough to come under these mathematical equations has been obtained. This experimental curve fits smoothly between the theoretical curve for very wide tubes and that for very narrow ones. It has been shown that the method of calibrating tubes by weighing a mercury thread is not affected to an important extent by a film of air between the mercury and the glass, except perhaps in very fine capillaries. The disturbing effect of ellipticity in the cross-section of the capillary is indicated. The difference between the capillary rise in air and *in vacuo* has been determined with 6 liquids. In most cases the effect on the surface tension is less than 0·5 %. The surface tensions of water, 72·73; benzene, 28·88; toluene, 28·43; ether, 16·96; chloroform, 27·14; carbon tetrachloride, 26·77; and dimethylaniline, 36·56, have been measured in the presence of air. Removal of air caused increases in the surface tension as follows: Water, + 0·02; benzene, + 0·14; chloroform, + 0·10; carbon tetrachloride, + 0·18; ether, + 0·05; dimethylaniline, + 0·10. The paper contains very full experimental details with numerous illustrations, and a concise account of the preparation of the liquids used. H. H. Ho.

1687. *The Relationship of Capillarity to the Lorentz Contraction and to the Relativity Principle; an Attempt towards the Practical Utility of these Hypotheses.* **R. v. Dallwitz-Wegner.** (Zeits. techn. Physik, 2. 6. pp. 160–165, 1921.)—Hitherto the consequences of the hypothetical Lorentz contraction upon the inner conditions of bodies have been scarcely noticed, and the present paper contains an attempt to apply these new principles for the explanation of physical properties, capillary phenomena being chosen for the purpose: the paper itself is mathematical throughout. The hypothetical Lorentz contraction combined with the relativity principle indicates that the Lenard force β decreases with the free paths of the molecules, and from other observations it is concluded that the positive molecular force of attraction decreases with the free paths; so that the capillary height decreases with the molecular force. A number of analogies are given in which, with rising temperature, *i.e.*, with increasing molecular force, certain magnitudes change; *e.g.*, the modulus of elasticity, the dielectric constant, and the electrical resistance. A basis is thus afforded for further investigation, which is simple and self-evident. Everything molecular being still obscure, all that is inexplicable is included in its domain, and the Lorentz contraction perhaps affords a working principle for further discrimination and elucidation. A table of results for 19 metals is included, in which the Lenard force β is given against bone-oil. H. H. Ho.

1688. *Interfacial Tension. I. Statical Measurement of Interfacial Tension in Absolute Units.* **W. C. Reynolds.** (Chem. Soc., J. 119 pp. 460–465, April, 1921).—Satisfactory measurements of interfacial tension can be made by determining the rise or fall in a capillary tube immersed in a second liquid (instead of being surrounded by air as in ordinary measurements of surface tension), provided that in every case the apparatus is wetted first with the liquid which has the greater surface tension, *e.g.*, usually with an aqueous solution rather than an organic solvent. It is essential also to use a machine-made and not a hand-made capillary; when this is done there is no difference whatever between the surface tension of water, as determined by capillary rise and as measured by Rayleigh's "ripple" method, the mean values in degrees per cm. being **76·7 at 0°, 73·6 at 18°, 70·0 at 36°, 64·8 at 69°, and 60·9 at 89°**; a change of surface tension with the age of the surface does not exist. The dynamical (falling drop) method of determining surface tension as commonly used gives results which on the average must be multiplied by **1·26** to correspond with the results obtained by the statical (capillary rise) method of measurement. T. M. L.

1689. *Interfacial Tension.* II. *Relation Between Interfacial and Surface Tension of Organic Solvents in Contact with Aqueous Solutions.* **W. C. Reynolds.** (Chem Soc., J. **119**. pp. 466–476, April, 1921.)—Provided that the measurements are made with mutually saturated solutions instead of with pure liquids, the interfacial tension, *e.g.*, between water and benzene, is given accurately by the difference between the surface tensions of the two liquids in contact with air. In some instances impurities present in the liquids may accumulate at the surface and give rise to a slow decrease of surface tension. For instance, commercially pure benzene contains an unascertained impurity which is adsorbed at the interface, but can be removed by shaking with fuming sulphuric acid, washing with dilute alkali and water, and distilling. A similar effect can be produced artificially by adding oleic acid (which has a lower surface tension) to benzene, or by using a mixture, such as a petroleum fraction. In the latter case the concentration at the interface is so rapid that the surface tension falls to one half when measured with slowly formed instead of with rapidly formed drops.

The relationship between interfacial and surface tensions holds good when one of the constituents is an aqueous solution of a salt or sugar. In the case of several colloidal sols however, *e.g.*, gelatin and gum, there is a slow fall of interfacial tension, as the sol concentrates at the interface. In the case of soap solutions, Rayleigh has shown that the surface tension at an age of 0·01 sec. is identical with that of water, but in the case of an interface with benzene the tension falls to from 75 to 21 % of that for pure water even in drops considerably under one second old.

T. M. L.

1690. *Structure of Compound Depressions.* **H. Ficker.** (Meteorolog. Zeits. **38**. pp. 65–70, March, 1921.)—The pressure changes at the earth's surface during the passage of a depression are only partly accounted for by the spreading of cold waves of polar origin in the lower troposphere [see Exner, Abs. 1137 (1920)], and their interaction with warm equatorial currents. Both mountain and aerological observations indicate that pressure changes are large even at high levels, and the author pictures three layers of the atmosphere as each playing a distinct part—(1) the lower half of the troposphere where cold polar and warm equatorial currents interact, (2) the lower half of the stratosphere where "cold" equatorial and "warm" polar currents interact, (3) the upper troposphere where there are no marked horizontal temperature gradients. The essential feature of the hypothesis is that the effects in the stratosphere are regarded as thermal rather than dynamical. The ensemble is termed a "compound depression" and most depressions are of this type. The pressure wave recorded by a barograph at the surface is compounded of that due to (1) and that due to (2) which is transmitted unchanged by the intermediate layer (3). The depressions in the stratosphere and lower troposphere, though related, in general move with different velocities, and this may produce a variety of different pressure curves at places at the surface. This and other consequences of the hypothesis are considered in some detail. M. A. G.

1691. *Transparency of the Atmosphere and Weather Prognostics.* **A. Gockel.** (Meteorolog. Zeits. 38. pp. 78–82, March, 1921.)—For 15 years the author has recorded at Freiberg, Switzerland, the occasions of visibility of certain distant mountains, in particular the Bernese Alps, 60 km. eastwards; these are here summarised, primarily as a test of the view that very clear air is a sign of coming precipitation. The occurrence of good visibility, measured in this way, is usually associated either with Foehn or anticyclonic conditions, the latter predominating in winter. It is more frequent in winter than summer, the average number of days per month on which the Bernese Alps were visible being :—

Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
10	13	10	5	6	5	5	7	7	10	12	11
4·2	4·2	2·2	0·9	1·3	0·7	0·5	1·4	2·2	2·8	4·4	5·1

where a second line is added taking account only of those cases of very great clearness. A table, giving for each month the percentage frequency of the occurrences of precipitation, one, two, etc., days after the visibility of the Bernese Alps, shows that it occurs within 48 hours on about 72 % of occasions, while a similar table shows that such visibility follows precipitation within 48 hours in about 64 % of the cases. A useful result is that of the remaining 36 %, as many as 85 % are followed by precipitation within 48 hours.

Another measure of transparency is the degree of polarisation of the sky light, which, except during presence of Ci. or Ci.St. veil, is greater the clearer the air. Polarisation above normal is usually followed by thunder in summer and precipitation in winter.

The number of condensation nuclei indicated by Aitken's method or of "air-planktons" as given by Weber's, does not directly affect the transparency, but may help in forecasting; *e.g.*, an unusually low value in the morning renders precipitation unlikely, at least on the same day.

Spectrophotometric measurements show that high intensity of blue in the sky light occurs with good visibility indicated by alpine observations, so that such measurements may have a use in forecasting. M. A. G.

1692. *Rate of Evaporation in Still Air.* **J. Würschmidt.** (Meteorolog. Zeits. 38. pp. 161–167, June, 1921.)—The rate of evaporation in still air, from the surface of water contained in a cylindrical vessel of radius

r, has been given by Stefan, from theoretical considerations, as $v = c\left\{\sqrt{(r^2 + h^2)} - h\right\}$, where h is the depth of the water surface below the rim of the vessel, c is a constant and v denotes the rate of evaporation per unit difference of wet and dry-bulb temperature. This formula really gives an upper limit to the rate of evaporation and in the present paper several more approximate formulae are obtained, which, for the case when h is small compared with r, reduce to $v = c\left\{r - \sqrt{(hr/2)}\right\}$. Experimental verification was sought and found. A vessel of radius 2·5 cm. was filled to the brim with water and placed on a balance. The whole was weighed at intervals and each time the wet and dry-bulb readings were noted. As the water surface fell in the vessel and h increased, a progressive decrease was found in the rate of evaporation per unit psychrometer difference, and plotting this against time a curve was obtained in good agreement with the theoretical curve $v = c\left\{r - \sqrt{(hr/2)}\right\}$, where h is known as a function of t from the experimental data. Further verification was obtained by experimenting simultaneously with vessels of different radii and with the water surface at different depths below the rims, and noting the good agreement between the values of c deduced from the observations of each. M. A. G.

1693. *Bristol Channel Tides.* **G. I. Taylor.** (Cambridge Phil. Soc., Proc. 20. pp. 320–325, May, 1921.)—The theoretical tidal increase which might be expected in a channel, whose breadth and mean depth both decrease uniformly from the open end and vanish at the head, are worked out. The results are compared with the Bristol Channel tide with good agreement, and it appears that the usual hydrodynamical theory of tides accounts quantitatively as well as qualitatively for the abnormally high tides which exist at the head of the Bristol Channel. W. A. R.

1694. *Isostasy.* **W. Bowie.** (Am. J. Sci. 2. pp. 1–20, July, 1921. Paper read before the Geolog. Club of Yale Univ., Feb., 1921.)—This paper is a general review of the subject, and presents the writer's latest opinions. The distribution of isostatic compensation vertically varies from place to place, but the average distribution for any large area approximates to uniform distribution. With regard to horizontal distribution, the results were in accord up to 40 miles from the geodetic station, but the area could not be extended to 100 miles. A correlation is established between the sign of the anomalies and the geological formation. Over areas of recent sedimentation (Tertiary) the sign is negative, owing to the lightness of the uncompacted material; over areas of Pre-Cambrian rocks there is generally a positive sign. The earth's crust is regarded as possessing no great strength, and the writer predicts that anomalies over river deltas will be found to have a negative sign. *Mountain building* is due to vertically acting forces and not to horizontal. Horizontal movements are incidental to vertical uplift, and are due probably to the fact that the base of the mountain system is usually large. The theory of isostasy cannot explain great changes in elevation, and there must be other causes. W. A. R.

1695. *New Determinations of the Density of Air at Geneva.* **A. Treuthardt.** (Comptes Rendus, 172. pp. 1598–1600, June 20, 1921.)—That the density of air at a given place, under standard conditions of temperature and pressure, is not constant, was first shown at Geneva by Guye, Kovacz and Wourtzel in 1910, and has since been confirmed both there and elsewhere. Some new determinations, made at Geneva in 1917, are here summarised and confirm previous results, also showing, as noticed by earlier investigators, that the density is above normal when the sample is collected at a time when atmospheric pressure is below normal, and vice versa. The samples are collected in balloons which are filled at 0° C. and under pressure of 760 mm., the air having been deprived of CO_2 and dried. At each determination a number of samples are examined and the mean is taken as the density at the time. The variations from time to time are of the order of several tenths of milligrammes per litre. The mean density from all the experiments of this series is 1·2928 gm. per litre, that found in 1910 and 1912 being 1·2930. M. A. G.

1696. *Air Density at Madrid and its Small Variations.* **E. Moles, T. Batuccas,** and **M. Payà.** (Comptes Rendus, 172. pp. 1600–1602, June 20, 1921.)—The determinations were made by the Geneva balloon method (see preceding Abs.), at a place 680 m. altitude, sufficiently remote from towns, etc., on 25 occasions spread over a period from July of one year to May of the next. The density obtained on each occasion is the mean from more than one sample. While the variation in the observed density of different samples collected at the same time in the same place is found to average 0·000 08 gm. per litre and rarely to exceed 0·0002, variations from time to time are found to reach 0·0008 gm. per litre, showing the latter to be a real effect and not due to observational errors. The law of Loomis-Morley is again verified, namely, that density is high when atmospheric pressure is low, and vice versa. On some occasions of strong insolation exceptions occur, high density corresponding to high atmospheric pressure. This is attributed to the formation of ozone, a view supported by a special experiment in which steps were taken to destroy ozone before determining the density, which was then reduced to an appropriate value. The mean density, from all experiments, is 1·29303 gm. per litre.

Inaccuracy of Density of Gases when referred to that of Air.—Because of the variations established by this and previous work, the authors insist that the practice of referring the density of gases to that of air should be abandoned. M. A. G.

1697. *Aurora of May* 13–15, 1921. **Rayleigh.** (Nature, 107. p. 392, May 26, 1921.)—Photographing the night sky spectrum every night, the author obtained a strong auroral spectrum on the nights May 13–14 and 14–15, showing the aurora line λ5578 and the negative bands of N, which were much stronger than the aurora line. On the second night ten heads of these bands were shown, in a range where Vegard's special expedition to the Arctic only showed six. On ordinary nights the aurora band can generally be photographed, but the N-bands have not been found in about 100 nights except on the two mentioned. On the third night the aurora band was fainter than usual and the N-bands not seen. W. W. B.

1698. *Earthquake Periodicity, Japan.* **C. Davison.** (Phil. Mag. 41. pp. 908–916, June, 1921.)—*Annual periodicity.*—Maximum epoch for the whole country in the case of strong earthquakes is Dec.-March; of slight quakes, Sept.-Oct. The max. frequency occurs in the winter in some parts, and during the summer in others. The smallness of the amplitude of the annual period for the whole country is in part due to this position in epoch. Submarine quakes not more than 10 miles from the coast have a winter maximum epoch, and those originating 20 miles out have the epoch in June. *Diurnal periodicity.*—The maximum period for early after-shocks is near midnight, and the semi-diurnal period variable. For later after-shocks the epoch returns after a period varying with the place to about noon, and the semi-diurnal period at Gifu to 8 or 9.

Speaking generally, the periodicity appears to be correlated with barometric pressure. W. A. R.

1699. *Aurora Borealis of the Night May* 14–15, 1921, *and Simultaneous Magnetic Phenomena.* **B. Lyot.** (Comptes Rendus, 172. pp. 1230–1231, May 17, 1921.)—A brief note on the aurora observed on the night following the central meridian passage of the important sun-spot group of May, 1921. The aurora was first visible at 0 h. 15 m., after the moon had set, in the form of a ray in the magnetic meridian, and subsequently developed, the rays diverging somewhat towards the zenith. Maxima of intensity were shown at 1 h. 4 m., 2 h. 10 m., and 3 h. 5 m. It was sufficiently bright at times to mask stars of the second magnitude. A variety of colours were shown by different parts—white (possibly a little green), intense red, and indigo. At maximum phase the rays reached the zenith and appeared to converge there. The sun-spot group was attended by magnetic disturbances, and in the night under consideration the amplitude of the magnetic needle exceeded one degree. The place of observation is not stated. M. A. G.

1700. *Personal Errors with Self-Registering Micrometer.* **J. C. Hammond.** (Astron. J. 33. pp. 155–157, May 20, 1921.)—By the use of an artificial star whose motion can be reversed and whose carriage automatically records its " transit " the absolute personal equations of five observers at the U.S. Naval Observatory were determined for stars of different declinations. With the possible exception of stars within 10° of the Pole, all observers were late by amounts of the order of one or two hundredths of a second. There is a tendency to get ahead of the slow-moving stars. Four of the observers were also tested with a disc representing the sun, and were all slightly later than for stars of the same declination. The relative personal equations are also tabulated, but these are not free from variations due to clock rate and other instrumental details. Between fifth and eighth magnitude three of the observers show practically no magnitude equation whatever. Corrections are also tabulated to show differences of fundamental places determined by each observer, reduced with his own clock error, for different declinations and circle positions. Some of these appear to be systematic, but the data are insufficient. It is not considered settled whether the motor-driven micrometer is better or worse than the hand-driven. W. W. B.

1701. *Differential Horizontal Refraction.* **W. B. Varnum.** (Astron. J. 33. pp. 157–158, May 20, 1921.)—Albany observations for clock error in 1907–18 show a well-marked term depending upon the time of day at which observations were made. A formula was assumed upon the hypothesis that this was due to horizontal refraction and evaluated for different declinations. The application of this reduced the probable error from ± 0·0336 sec. with an uncertainty of ± 0·0048 to ± 0·0259 with uncertainty of ± 0·0031 sec.

Full details will appear later. W. W. B.

1702. *Accuracy of Transits with Self-Registering Micrometer.* **F. Kromm.** (Bull. Astronomique, 1. No. 3. pp. 147–149, 1921.)—The author selected 26 Pleiades stars and asked Trousset in 1911 to observe each six times with a Gautier registering micrometer. Owing to bad weather the observer had not completed the programme before his retirement, and Stapfer carried on instead. As, however, the last-named observer simply included the special observations in his ordinary routine programme, whereas Trousset confined himself to the special observations only, there is a marked difference between the precision obtained in the two cases. Moreover, Trousset worked single-handed and limited himself to four observations each night, while Stapfer had an assistant to read the circles for him, to save time, as he was doing regular meridian work. His probable error is more than half as large again as Trousset's.

The author, in discussing the results, draws attention not only to the theoretical advantages of the self-registering micrometer, but also to the danger of haste or of slight inattention. He considers that the chronographic method reduced the probable error, which averaged $0''\cdot7$ for the eye-and-ear method, to $0''\cdot5$, and that the self-registering micrometer has again reduced it in a similar proportion. W. W. B.

1703. *Isosceles Solutions of the Problem of Three Bodies.* **J. Chazy.** (Bull. Astronomique, 1. No. 3. pp. 171–188, 1921.)—A particular case of these solutions is Lagrange's equilateral. Another is Euler's three bodies in a straight line provided the masses of the two outer ones are equal. There are also three other cases given for the first time by Fransén: (1) Motion with an axis of symmetry but not rectilinear; (2) motion with a plane of symmetry but not in one plane; (3) plane movement with an axis of symmetry, particular case of (1) and (2). The author investigates the equations derived from the general form of the problem and ultimately reaches the conclusion that if unequal masses are placed at the equal angles of an isosceles triangle the isosceles solution must reduce to Lagrange's equilateral. He gives preliminary consideration to the three cases mentioned above, finding that the motion with an axis of symmetry admits of a simple analytical representation whatever be the initial conditions with repulsive forces. He proposes to amplify his conclusions in a future memoir. W. W. B.

1704. *Stability with the Law of the Cube of Distance.* **J. Chazy.** (Bull. Astronomique, 1. No. 3. pp. 151–163, 1921.)—The author quotes Jacobi's theorem that if n material points mutually attract in the ratio of their masses and the inverse cube of their distances they form an unstable system. After defining stability, he considers the possibility of an exception to Jacobi's generality, for particular cases; especially that of collision between any of the masses. Starting with the simple case of two bodies, or of n bodies only two of which have appreciable masses, he proceeds to that of three bodies, of which two collide, and generalises for n bodies and all possible collisions. His conclusion is that though mathematically he can find an exception to Jacobi's rule, yet physically there can be none, so that the special case must be imaginary.

He then considers intermediate laws between Newton's inverse square, and the hypothetical inverse cube, and also those outside these limits. In all cases he finds the mutual distances tend to reach definite limits. Obviously if the inverse power is the cube or greater, bodies receding undergo an attraction which diminishes so rapidly that they are not likely to return, whereas bodies approaching are bound to collide. W. W. B.

1705. *The Recent Large Sun-spot Group.* **H. W. Newton.** (Nature, 107. pp. 399–401, May 26, 1921.)—The author gives an illustrated account of the circumstances of the May sun-spot. It was exactly on the solar equator, instead of in latitude 10°, which ordinarily corresponds to the present phase of the sun-spot period, about four years after maximum. It developed in an unusual way, two spots several degrees apart in longitude developing from a single irregular spot, instead of from two separate nuclei. The magnetic storms associated with the spots took place rather before the spots reached the central meridian, instead of about a day after. It is suggested that the group may be associated with abnormal magnetic fields in the sun. W. W. B.

1706. *Einstein Displacement of Solar Spectrum Lines.* **H. Buisson** and **C. Fabry.** (Comptes Rendus, 172. pp. 1020–1022, April 25, 1921.)—The author recalls the observations by Rowland and by Jewell in and after 1896 of such displacements, mostly towards the red, but not infrequently towards the violet. Rowland suggested that the former were due to pressure in the reversing layer of the solar atmosphere, but found no explanation in the case of the latter. The author, in 1909 [Abs. 786 (1909)], traced the numerous anomalies observed by Rowland to unsymmetrical broadening of lines in the electric arc spectrum, finding that when the arc in air was replaced by an arc *in vacuo* the anomalies disappeared, the displacements being always towards the red. Now Perot has shown quite recently [Abs. 1024 (1921)] that in the case of a group of magnesium lines in the solar spectrum the pressure effect is negligible, and that the displacements of the solar lines relatively to those of an arc in an atmosphere of very low pressure are in accordance with Einstein's theory. This led the author to re-examine the results of his observations on the iron lines in the solar spectrum, and he finds that the mean displacement of 22 lines of wave-lengths between 4000 and 4500 is 0·0076 Å., Einstein's value being 0·0009, and that of 10 lines of wave-lengths between 5100 and 5500 is 0·0127, Einstein's value being 0·0111. Since the differences are of the same order as that of observational error, the agreement may be considered as perfect, so that the observations confirm Perot's conclusion that the presence of the reversing layer of the solar atmosphere is negligible, and the displacements are consequently adequately accounted for by the Einstein-effect alone.

G. W. de T.

1707. *Displacement of Spectral Lines by a Gravitational Field.* **H. J. Priestley.** (Nature, 107. p. 585, July 7, 1921.)—Reference is made to a previous letter [see Abs. 1267 (1921)]. The metric of the field of a single gravitating centre is discussed, and it is argued that, assuming that the observer's time-scale bears to the time-scale at his world-point in the Riemann space the ratio $1 : f(r)$, the scales of the Euclidean systems of two different observers vary inversely as $\gamma^{1/2}f(r)$. This variation of

scale has no effect on the Mercury problem or on the deflection of a beam, but is of fundamental importance in the displacement of spectral lines.
A. B. C. L.

1708. *Einstein Spectral Shift.* **O. Lodge.** (Phil. Mag. 41. pp. 944–945, June, 1921.)—Referring to Priestley's recent paper [Abs. 1267 (1921)] on this subject, Lodge here questions whether Priestley succeeds in establishing "that the confirmed gravitational deflection of a ray can be equally well obtained without depending on the principle of least time, or any other pre-relativity physics, and therefore without admitting the constancy of time period which that principle apparently implies." [See Abs. 357 (1921)].
A. W.

1709. *Accelerations of Sun and Moon.* **H. Jeffreys.** (Brit. Astron. Assoc., J., Jan., 1921. Nature, 107. p. 281, April 28, 1921.—Abstract.)—[See Abs. 687, 688 and 1144 (1920).] Taking the values of Fotheringham for increase of velocity per second per century, 21″·6 for the moon and 3″ for the sun, the author attributes 12″·2 of the lunar figure to the diminution of eccentricity of the earth's orbit. The remaining 9″·4 and the 3″ for the sun he ascribes to tidal friction which lengthens the day. This slowing of the earth's rotation sends the moon further away, and thus cancels a great deal of the apparent acceleration, and this accounts for the lunar tidal figure being only about three times that of the sun instead of thirteen times. The tidal friction is greatest in the Behring Sea, but is sensible in many other regions, such as the Irish Sea.
W. W. B.

1710. *Physical Constitution of Sun and Stars treated as Perfect Gas.* **A. Véronnet.** (Bull. Astronomique, 1. No. 2. pp. 83–129, 1921.)—The author starts with the hypothesis of uniform density, and seeks the ratio of the central temperature to that of the surface. He concludes that for all stars, whatever their density and temperature, the central temperature is about double that of the surface, on the hypothesis of uniform density, which makes the variability of temperature a maximum. In no case can this central temperature reach thrice that of the surface. Thus the centre of the sun cannot reach 18,000°. He draws curves showing the progressive change of temperature from centre to surface for the extreme cases of max. density and max. expansion, finding them very similar: all real curves must lie between the two. Physical equilibrium requires, for condensed bodies like the sun, a temperature increasing rapidly from the surface inwards, nearly the whole of the interior being thus at the central temperature. The less the density the slower is this increase inwards. The curve of increase is approximately parabolic, and the mean temperature two-thirds of the central temperature. He gives also the variation for any layer according to density.

For a homogeneous star expanding or contracting, the central temperature reaches a maximum when the density is one-fourth of the limiting density at the centre. For a constant cubical expansion this max. temperature would be 75,000,000° for a body like the sun, but with radius 25·5 times bigger and a density equal to that of hydrogen. With half the density the figure would be 57,000,000°, and the radius 34 times that of the sun. For constant linear expansion the max. temperature would be 3,000,000°, and the radius 600 times that of the sun.

Reversing the process and working back to a cold primitive nebula in physical equilibrium with uniform density, the central temperature will increase with contraction up to a max. value, as given above (57,000,000° and radius 34 times that of the sun). The mean temperature would have a max. value of 26,000,000°, and radius 29 times that of the sun. It is evident, however, that this does not represent the facts, for the max. value is not reached at first, because the nebula expands by radiation instead of contracting, and afterwards because contraction, even acting instantaneously without loss of heat, could not raise the temperature sufficiently, and lastly because the molecules would disperse under so great a velocity as the temperature would set up. No star, therefore, can pass through this temperature maximum, and there must be a gap between the cool nebula and the radiating star. In a perfect gas both the central and the mean equilibrium temperatures would increase indefinitely with contraction, and there would be no maximum. Thus the sun's mean temperature would be 10,000°, and its central temperature 25,000°.

In the case of a highly condensed star expanding, the max. temperature would be reached first near the surface and then by successive layers within that. As each internal layer reaches its maximum, those outside it cool by expansion, and form the atmosphere; those within gain heat in expanding, like liquids or solids, and form the nucleus. When the centre reaches its max. temperature the whole mass behaves as a gas, and there is no longer any solid core. Thus the max. temperature of a star is like the critical temperature of a gas, below which alone the liquid state is possible.

In the case of a cool nebula remaining homogeneous during contraction, the temperature increases fastest at the centre, and then as the temperature in the outer layers goes on increasing the core begins to cool; and this stage extends outwards until the whole mass cools and contracts like a liquid. W. W. B.

1711. *Attempt to Photograph Spectrum of Lower Chromosphere, at Partial Solar Eclipse,* 1921 *April* 7–8. **H. F. Newall.** (Roy. Astron. Soc., M.N. 81. pp. 482–485, May, 1921.)—A previous attempt having been successful [see Abs. 1500 (1912)], preparations were made at the Solar Physics Observatory, Cambridge, to repeat the experiment more carefully. An image of the sun 168 mm. in diam. was thrown on the slit of an auto-collimating spectograph with a 14-ft. camera and a 6-in. Michelson grating. Photographs were taken in the first-order spectrum (dispersion 1 mm. to 4·02 tenth-metres in region λ4050 to 4420; slit width, 0·042 mm.; slit inclined at 10° to tangent to sun's limb. Conditions appeared favourable, and the programme was carried out: only Hγ and Hδ appear as bright lines, and no bright metallic chromospheric line appears on the plates, so the experiment failed. The effect of prominences which happened to cross the slit is discussed, with measurements of the width of Hγ and Hδ at different distances from the sun's limb, and consequently different exposures owing to the moon's motion.

A photograph obtained with an instrument giving a smaller image, 40 mm. in diam., was equally disappointing. Other photographs were taken, with slit just within the moon's limb parallel to the tangent, to test the possibility of a lunar atmosphere, causing absorption lines, but no evidence was found except the bright reversals of H lines, which are more probably due to telluric scattering of the light of a large flocculus close to the moon's limb. W. W. B.

1712. *Partial Solar Eclipse,* **1921** *April* **7** *; Spectroscopic Observations of Reversing Layer.* **A. L. Cortie** and **J. Rowland.** (Roy. Astron. Soc., M.N. 81. pp. 485–486, May, 1921.)—At Stonyhurst the Browning 12-prism spectroscope was used with a dispersion of 8 prisms of 60°. The region under observation was from the *b* group $\lambda 5167$ to 5400 to include the corona line $\lambda 5303$. All the lines were reversed, the bright lines tapering to a point, showing decrease of pressure. The longest lines were the Mg lines of the *b* group, and probably Ca $\lambda 5266$. The coronal radiation at $\lambda 5303$ was not seen. If present it was masked by the brightness of the chromospheric lines. W. W. B.

1713. *Greenwich Observations of Solar Eclipse,* **1921** *April* **7.** (Roy. Astron. Soc., M.N. 81. pp. 480–482, May, 1921.)—The sun's image was projected on a screen, and at regular time-intervals observers marked the position of the cusps, each observer confining his attention to one cusp. The scale was determined by marking off the sun's diameter in a direction parallel to line of cusps. The observations were reduced so as to give a more accurate time of contact than can be obtained by direct observation. Photographs obtained close to line of contact were similarly reduced. Photographs were also taken near mid-eclipse. From all the observations the mean resultant correction to the moon's tabular place is $+ 0{\cdot}88$ sec. in R.A. and $+ 4''{\cdot}75$ in Decl. The excess of width of crescent over its computed value was $3''{\cdot}29$, taking mean of four observations. This may be due to photographic irradiation, ascribing half the effect to each limb. W. W. B.

1714. *Sun-spot Group and Magnetic Disturbances,* **1921** *May* **8–21.** **A. L. Cortie.** (Roy. Astron. Soc., M.N. 81. pp. 515–520, June, 1921.) —Appearing in a region long inactive, the spot group was close to the solar equator at a time when the earth's mean heliographic latitude was small, so the author considers a great magnetic storm was probable. In a previous paper [Abs. 1476 (1921)] he had given details of the magnetic disturbance. The storm was of very long duration, longer than any recorded at Stonyhurst since 1882 Nov. 11–21 ; also marked by a great spot. This year's magnetic disturbance lasted from May 12 to 21. The author gives a detailed comparison of the intensity of the storm in different magnetic elements with the area and position of the sun-spots. He rejects the idea of a single stream of energy directed from a spot area, and suggests that the long-continued disturbance points rather to divergent streams of particles from the active region of the sun, spreading into clouds. He adds an account of the magnetic disturbance as registered at the Tortosa Observatory, Spain. W. W. B.

1715. *Abnormal Rotation Period of a Spot on Jupiter.* **F. Sargent.** (Observatory, 44. p. 185, June, 1921.)—Observations made by the author on May 16, 18, 23 and 25, of a very dark spot on the N. edge of the S. equatorial belt of Jupiter, give a rotation period for it of 9h. 51m. 47s., which lies between the accepted values of System I and System II. He thinks that the discordance of 80 or 90 seconds, by which the spot moves more slowly than its surroundings, is well established, and without precedent, and cannot be attributed to errors of observation. W. W. B.

1716. *Remarkable Spot on S. Equatorial Belt of Jupiter.* **F. Sargent.** (Roy Astron. Soc., M.N. 81. pp. 521-522, June, 1921.) [See preceding Abs.]—Noticed first as a dark marking on the N. edge of the S. equatorial belt, the spot was found to be of great intensity, elongated, with a penumbra-like shading round it, and being observed through a period covering 44 rotations gave a result of 9h. 51m. 45s., or about 1½ min. slower than the usual period for that part of the planet. Examination of previous observations suggests that not a single spot but an appreciable area is involved in this unusual rate of motion. The author suggests volcanic agency throwing out material into a latitude of different rate of rotation. The spot projects into the equatorial zone, and must be watched to see whether it maintains its unusual period or tends to conform to that usual in the region.

A very few examples are quoted of similar abnormal periods observed in the past. W. W. B.

1717. *Rotation of the Inner Planets.* **L. Rodès.** (Observatory, 44. pp. 182-184, June, 1921.)—In reply to Slipher [see Abs. 388 (1921)], the author defends his suggested spectrographic method of detecting rotation of the inner planets. He lays stress on the fact that the method, though laborious, enables every one of the numerous spectrograms of Venus to be used for testing purposes, to compare with the rule: Venus East, residuals towards violet; Venus West, residuals towards red. He points out that much smaller displacements than those in question are already being measured at Mt. Wilson. He traverses in detail certain specific objections raised by Slipher, and concludes with an actual trial of his method on two spectrograms obtained by Evershed in 1919. He does not consider the evidence at present sufficient to decide between the well-known short and long periods generally offered as alternatives for the rotation of Venus, nor in respect of Pickering's intermediate 68-hour period, but asks for as many spectrograms as possible to be obtained at certain elongations of Venus—east and west of the sun, and measured and compared according to his suggestions. W. W. B.

1718. *Bright Areas on Mars.* **R. Jarry-Desloges.** (Comptes Rendus, 172. pp. 1473-1474, June 3, 1921.)—The north polar cap of Mars, from observations in Algiers, appears to be very eccentric with reference to the axis of the planet. Various positions are given in a diagram, with dates, and it is to be noted that on April 25, 1920, the actual pole was outside the polar cap. Nix Olympica [see Abs. 1562 (1920)], or at any rate the white patch in which it is situated, seems to have occupied the same position in 1916 as in 1918 and 1920, according to the records of the Setif Observatory. W. W. B.

1719. *Radiative Equilibrium; Effect of a Strong Absorption Line.* **E. A. Milne.** (Roy. Astron. Soc., M.N. 81. pp. 510-515, June, 1921.)—A dark line shows that for some particular wave-length more energy is absorbed than emitted, but for radiative equilibrium this deficiency must be made up elsewhere. When there is no selective absorption the temperature gradient is roughly proportional to the coefficient of

absorption and to the total flow of energy, but when any region shows selective absorption, its temperature gradient cannot get the energy through [see Abs. 997 (1905)], and so it accumulates, increasing the temperature gradient in the neighbourhood. The author goes into the question of the distribution of this accumulated energy, and concludes that the effect of an absorption line lying on the violet side of the maximum is to brighten slightly the whole of the continuous spectrum, but if on the red side of the maximum then the effect is to brighten the violet-ward side and darken the red-ward side of a certain other bounding wave-length, whose position (always to the red side of maximum) approaches the maximum more closely, the nearer the absorbing line is to the red. In other words, the presence of intense absorption lines involves a redistribution of energy, taking the form in general of a strengthening of the violet with possible weakening of the red, and a slight shift of maximum towards the violet. The selective absorption is presumed to take place in all layers from which photospheric light is received, and not from a single thin layer near the boundary. It is also assumed that the mechanism of radiation and absorption is adequate for the free transformation of energy into heat, or into energy of a different wave-length.
W. W. B.

1720. *Magnitude Curves of Three Short-period Variable Stars.* **C. Martin** and **H. C. Plummer.** (Roy. Astron. Soc., M.N. 81. pp. 468–469, May, 1921.)—The three stars are RR Leonis, Y Aurigæ, and UU Cassiopeiæ. *RR Leonis.*—42 exposures were made at Dunsink from 1919 Feb. 24 to 1921 Apr. 7, and the elements of maximum are J.D. 2422014·378 + 0·452372 E. *Y Aurigæ.*—58 exposures were made between 1917 Dec. 14 and 1921 March 14, and the elements of maximum are J.D. 2422645·531 + 3·859445 E. *U U Cassiopeiæ.*—44 exposures were made between 1917 Nov. 7 and 1921 Feb. 25, and the elements of maximum are J.D. 2422745·09 + 4·31304 E. Some irregularities in the light-curves are discussed, and Fourier series given suggesting subsidiary variations.
W. W. B.

1721. *Orbit of* Σ *554 = 80 Tauri.* **W. H. van den Bos.** (Roy. Astron. Soc., M.N. 81. pp. 474–478, May, 1921.)—This star was probably near max. separation when discovered by Struve, and no measures are available near minimum separation, as the fainter star is lost in the brightness of its companion. Two orbits are suggested, one of which fits the old observations better, and the other the more recent ones. The two periods are respectively about 148 years and 150 years; and the author gives reasons for preferring the first orbit. He gives a 5-year ephemeris till 1945, after tabulating the residuals between all observations and his computed positions. The combined mass appears to be about 2¼ times that of the sun.
W. W. B.

1722. *Variation of Linear Scale of Stellar Photographs with Size of the Star Image.* **F. A. Bellamy.** (Roy. Astron. Soc., M.N. 81. pp. 531–535, June, 1921.)—The author gives a full account of the circumstances under which plates of the same region (22° South) came to be measured at Oxford from different observations; notably from the Cape and from Hyderabad; in accordance with a suggestion that plates should be taken at northern and southern observatories. The size of the images appears to have considerable effect, easily tested for any star by comparing short and long exposures. It is found that the Hyderabad object glass makes images grow away from the centre of the field, while the Cape object glass makes them grow towards the centre. The Oxford o.g. shows no sensible effect of this kind, but the point should be tested at all observatories, and this could be done by examining plates on which 20-sec. and 6-min. images have been taken. Any effects of this kind that can be found imply corrections to the brighter stars already measured from the 6-minute exposures, or to the constants derived from these measures to make them applicable to fainter stars. W. W. B.

1723. *Stellar Magnitude Scales of Astrographic Catalogue.* XVI. *Cordoba Magnitudes for* – 27°, – 29°, *and* – 31°, *with Remarks on the Whole Region* – 15° *to* – 43°. **H. H. Turner.** (Roy. Astron. Soc., M.N. 81. pp. 525–531, June, 1921.)—The counts given for the three zones are analysed by the adopted process [see Abs. 1148 (1920)]. As compared with adjacent zones, the relation between star density and star magnitude shows a weak link in this neighbourhood. W. W. B.

1724. *On H-absorption Lines in Nova Geminorum II.* **W. H. Wright.** (Roy. Astron. Soc., M.N. 81. pp. 501–509, June, 1921.)—In a further contribution to the discussion [see Abs. 829 (1921)] the author brings fresh evidence in support of his contention that the Doppler-effect is not proved to be a fully satisfactory explanation of the phenomena noted. Sometimes the displacement appears proportional to the wave-length, and sometimes not. It is not fair to select one class of evidence and reject or explain away the other. He points out similar difficulties in other groups than H, such as Fe and Ti, and lays stress on the importance of giving full attention to H_α, which is so far removed from the rest of the group, and so offers a more accurate scale-check. He appeals to Stratton's own notes, proving that only on March 25, 1912, was the displacement approximately a linear function of the wave-length, having been apparently a quadratic function on March 22 and March 23. Traversing Stratton's mode of explaining away the disagreement as a broadening towards the violet, he points out that when reduced to figures this means that broadening can displace the red edge of a band to the violet side of the centre of the band, which is too great an assumption.

He still wishes to leave the door open for other possible theories, and objects to the exclusion of H-data from the investigation. W. W. B.

1725. *Eclipsing Variable U Cephei.* **R. S. Dugan.** (Nature, 107. p. 373, May 19, 1921.)—This is a note on a previous paper by the author [see Abs. 223 (1921)]. The primary star of type Ao is totally eclipsed, so that the spectrum of the secondary is isolated, and it is announced by Miss Cannon, as of type Ko. Both would therefore appear to be giants. The secondary minimum being an annular eclipse, gives information about the degree of darkening at the limb. The limb-light is taken finally as one-third that at the centre. The orbit is sensibly circular, and the radii of the stars are approximately one-fifth and one-third of that of the orbit. Evidence of tidal evolution is adduced.
W. W. B.

1726. *Photographic Catalogue of Messier* 15. (Univ. Sternwarte, Bonn, Veröff. No. 15. Nature, 107. p. 311, May 5, 1921.—Abstract.)

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—Two exposures were made on this bright globular cluster, on 1916 Nov. 16 and 1917 Sept. 24, by Küstner, with exposures of 150 mins. and 90 mins. respectively. Eight reference stars are fully discussed, in regard to position and proper motion, and a catalogue is deduced giving magnitudes and rectangular coordinates of 1137 stars in the cluster. One star of 8th magnitude is probably seen projected against the cluster, the stars of which range from 13 to 16½ magnitude: after a few decades repeat photographs should make it possible to identify all stars projected against the cluster, but centuries must elapse before motion in the cluster itself can be expected. W. W. B.

1727. *Proper Motions of Stars in the Pleiades.* **W. M. Smart.** (Roy. Astron. Soc., M.N. 81. pp. 536–547, June, 1921.)—Plates with the film side away from the stars were taken at the Cambridge Observatory for direct comparison with others taken several years ago in the usual way. There is the drawback that three times the exposure is required, but other considerations, such as the reduction by half of the amount of measuring, outweigh this. The proper motions derived from the comparison-plates being bound together film to film, so that the images of the same star can be viewed together in the micrometer, appear to be as accurate as those measured in the usual way with an intermediary réseau system. Tables of comparison with the results of Stratton, Lagrula, and Kromm are given. The diagram of the Cambridge results confirms the accepted cluster-motion in position angle 158°, and the non-cluster stars seem to be equally distributed on either side of the line of parallactic motion in position angle 146°. W. W. B.

1728. *Spectrum of φ Cassiopeiæ in Relation to those of α Cygni and γ Cygni.* **W. J. S. Lockyer** and **D. L. Edwards.** (Roy. Astron. Soc., M.N. 81. pp. 495–501, June, 1921.)—Few stars have been found in classes A to F of ascending temperature, with spectra resembling that of α Cygni, the typical giant A star. The cause of this dearth may be the rapid evolution at this stage. In Lockyer's 1902 catalogue of 470 of the brighter stars only η Leonis belongs to this class. In the more recent list of 1150 stars from the Lockyer Observatory, three more have been found, μ Orionis, 13 Monocerotis, and 9 Persei. The present paper deals with a fresh addition to the list, φ Cassiopeiæ, which occupies a position intermediate between α Cygni and γ Cygni. Most of the enhanced metallic lines are intermediate in intensity between those of α Cygni and γ Cygni, but those of Sr appear of maximum intensity in this star.

Search through other catalogues resulted in a list of seven stars of similar type, ε Aurigæ, α Leporis, α Carinæ, θ Scorpii, ι Scorpii, 34 Draconis, and 45 Draconis. Eight other stars, α Persei, ο Leonis, χ Leonis, 89 Herculis, π Sagittarii, ν Aquilæ, η Aquilæ, and δ Cephei, are intermediate between φ Cassiopeiæ and γ Cygni. In regard to these the authors consider the Mount Wilson classification better than that of the Revised Harvard classification. A plate is given showing for the region from H_β to H_ϵ the evolution between stages represented by α Cygni, α Leporis, φ Cassiopeiæ, and γ Cygni, and also the difference between a typical giant (ε Aurigæ) and dwarf (Procyon) of similar type. W. W. B.

LIGHT.

1729. *New Registering Microphotometer.* **W. J. H. Moll.** (Phys. Soc., Proc. 33. pp. 207–215; Disc., 215–216, June 15, 1921.)—A diminished image of a slit, on which the filament of a half-watt lamp is focused, is projected by means of a microscope objective on to the photographic plate or other object of which the absorption is to be measured. A second similar objective focuses an image of the slit, magnified up to its original size, on a second slit behind which is mounted a sensitive thermopile of the author's own design connected to an improved D'Arsonval galvanometer. By suitable gearing to an electromotor the photographic plate is given a slow motion at right angles to the beam of light, and at the same time a drum of photographic paper, on which the spot from the galvanometer is focused, is caused to rotate at a suitable rate. A record is thus obtained of the density of the plate at different parts encountered by the beam of light. The arrangement is dead-beat and so quick in response that intensity curves of close spectrum lines, Zeeman triplets, etc., are accurately recorded. AUTHOR.

1730. *The "Kingsley" Shutterless Continuous-Feed Kinematograph.* **R. J. Trump.** (Phot. J. 61. pp. 261–265; Disc., 265–268, June, 1921. Optical Soc., Trans. 22. No. 2. pp. 75–82; Disc., 82–83, 1920–1921.)—A more detailed account of the "Kingsley" kinematograph projector which has been previously described by the author [see Abs. 837 (1921)]. A. E. G.

1731. *Scattering and Diffraction of Light by Mist and Clouds.* **R. Mecke.** (Ann. d. Physik, 65. 3. pp. 257–273, June 14, 1921.)—The discussion here given is concerned with the scattering of light by particles of radius 1 to 30 μ. Expressions are obtained for the intensity of the scattered light, and the results are illustrated by several diagrams. [See also Mallock, Abs. 1550 (1921).] A. W.

1732. *Light and Electrons.* **O. Lodge.** (Phil. Mag. 42. pp. 177–183, July, 1921.)—Referring to a previous paper [Abs. 1254 (1921)], if it is ever possible to separate or tear asunder a positive and a negative electron by means of light-vibrations, it would seem likely that the uniting force must at first follow the law of direct distance, in order that the excited vibrations shall be isochronous whatever the amplitude, and therefore cumulative in response to waves of definite frequency. The opposite charges may be thought of as initially united by an elastic thread of zero length, which is gradually elongated as the charges separate and vibrate or revolve about one another till it snaps. Very soon after this connection is broken, the ordinary inverse-square law must supervene, and thereafter hold for all greater distances. Following up this reasoning, expressions are obtained for (i) the critical distance at which an electron can escape, (ii) the critical velocity, and (iii) the critical frequency. These expressions are all of the right dimensions. Numerical calculation gives for the critical distance the value $0{\cdot}53/10^8 N$ cm., where N is the atomic number; so break occurs inside the conventional boundary of the atom, even for hydrogen, and at still smaller distances for substances of greater atomic weight. The critical frequency of the radiation most suitable for expelling an electron from a given element is $n = 4 \cdot 1 \times 10^{16}N^2/2\pi$, which is $6 \cdot 53 \times 10^{15}$ for hydrogen, attaining a value $5 \cdot 5 \times 10^{19}$ for uranium. The critical velocity with which an electron is expelled is $v = 2 \cdot 18 \times 10^8N$, and this reaches two-thirds the speed of light for $N = 92$. At that speed, however, the inertia would have increased enough to make the break occur rather earlier.

The latter part of the paper discusses the question of atomic instability, reference being made to the cumulative effect of random stimuli, and to the effect of temperature. A. W.

1733. *Majorana's Light-Speed Measurements.* **J. H. Jeans.** (Nature, 107. p. 42, March 10, and p. 169, April 7, 1921.)—In reply to a criticism of a statement in a recent paper [Abs. 1201 (1921)], the author points out that it *is* possible to compare two speeds along the same unidirectional course, and that this is Majorana's claim. Consider the problem in terms of an ether and a Fitzgerald-Lorentz contraction. According to the Michelson-Morley experiment, the double journey time is $l_0(1 - u^2/c^2)^{1/2}[1/(c - u) + 1/(c + u)] = l_0(1 - u^2/c^2)^{1/2}[1/(c - u + \alpha) + 1/(c + u + \beta)] \ldots (2)$, where $c + \alpha$, $c + \beta$ are the respective speeds through the ether, in virtue of the Michelson-Morley result. Hence $(2c + \alpha + \beta)(c^2 - u^2) = 2c(c - u + \alpha)(c + u + \beta) \ldots (3)$. Now impose a further speed v of the whole Michelson-Morley apparatus, so that its speed through the ether becomes $u + v$. Majorana's first result [Abs. 50 (1918)] shows that β is unchanged. His second result [Abs. 281 (1919)] shows that α is unchanged. Hence the double-journey-time is obtained by replacing α by $u + v$ in (2), and the Michelson-Morley results require that (3) shall remain true when $u + v$ replaces u. Since Majorana's results held over a considerable range of values of v, it appears that (3) must be true for a whole range of values of u; whence $\alpha = \beta = 0$, and the two terms in (1) must represent separately the times of the inward and outward journeys. In relativity language—when x, t, x', t' are related by the Lorentz transformation, the Michelson-Morley and Majorana results together show that on both journeys light travels with the same constant speed c.

In the second letter, the author, after a caution against indiscriminate mixing of the conceptions of the "relativity" and "the ether and Fitzgerald-Lorentz contraction" schemes, discusses the problem in "relativity" terms, as follows: The light-source of the Michelson-Morley experiment has a world-line AB and the mirror has a parallel world-line PQ. A light signal is sent from source to mirror and back to the source. Its emission from the source is represented by a point A on the world-line AB, its reflection by a point C on the world-line PQ, and its return to the source by a second point B on the original world-line AB from which it started. The Michelson-Morley experiment gives us knowledge of the absolute interval AB, but none at all of the position of C on the world-line PQ of the mirror. So far as the Michelson-Morley experiment alone is concerned, the directions of AC, CB in the continuum are unknown. The author maintains that the experiments of Majorana fix these directions for us, and so fix the position of C. The light signal then moves entirely in the plane of the world-lines AB and PCQ. In it take x and ct as coordinates for a particular observer, then for any observer, the lines $x = \pm ct$ are the bisectors of the angle between his axes of length and time, and a world-line parallel to either represents for every observer motion with the same speed c, which each will independently call the speed of light. Now Majorana's experiment showed in effect that the direction in the continuum of the world-line of light from a source or mirror moving relative to him was the same as that of the world-line of light from a source or mirror at rest relative to him. The directions were obtained by measuring their inclinations to the experimenter's special axes of time and space, but when the directions have been shown to be the same the observer's axes fade from view and the identity of direction becomes absolute. It now follows that the rays of light in a Michelson-Morley apparatus, moving with any velocity whatever, have world-lines parallel to these two special directions. Or, to come back to common language, both the outgoing and returning signals move with the velocity of light. The conclusion is, of course, subject to the limitations of Majorana's experiments—limitations which, it ought to be added, the author himself states with scrupulous care. G. W. DE T.

1734. *Relativity and the Velocity of Light.* **C. O. Bartrum, J. H. Jeans.** (Nature, 107. pp. 42–43, March 10, 1921.)—C. O. Bartrum criticises the article by J. H. Jeans [see preceding Abs.], in which recent experiments of Majorana are referred to. The experiments [see Abs. 50, 927, and 1087 (1918)] were designed to show the constancy of the velocity of light when reflected by a moving mirror, or when issuing from a moving source. Bartrum thinks that the experiments do not bear the interpretation which he understands Jeans to put on them, and that the experiment has not yet been devised that will enable a comparison to be made between the velocity of light on its outward and return journey along the same path, or that will give a measure of the velocity on a single journey. Jeans agrees with the second part of the above statement, and points out that the impossibility of an experiment being devised which can measure the velocity of light in a unidirectional course is, in effect, the primary postulate of the theory of relativity. He believes, however, that it is possible to compare two velocities in opposite directions along the same unidirectional course, which is what Majorana claims to have done. H. N. A.

1735. *Atmospheric Refraction.* **A. Mallock.** (Nature, 107. pp. 456–457, June 9, 1921.)—The author gives a proof of the theorem that "the course of a nearly horizontal ray of light is a circular arc having a radius of 14,900 geographical miles." He points out that the distance of the sea-horizon is greater when refraction is considered, than when it is ignored, nearly in the ratio 7 to 6. If an atmosphere of the same height and density as that of the earth covered a globe of 14,900 miles radius, he claims that an elevation at any point of the surface would be visible from any other point, and that a light at one end of a diameter would appear to an observer at the other end as a bright line round the horizon.

W. W. B.

1736. *Density, Refractive Index, and Dispersion of Gaseous Nitrogen at its Boiling Temperature.* **E. Gerold.** (Ann. d. Physik, 65. 1. pp. 82–96, May 13, 1921. Extract of dissertation, Leipzig.)—In a paper by Augustin [see Abs. 1200 (1915)] the refractive index of liquid and corresponding gas was determined experimentally for the same temperature. To obtain the true refraction behaviour, the refractive index and density of the gas at its boiling temperature were calculated by means of a dispersion formula proposed by Scheel utilising the Lorenz-Lorentz refraction formula, and assuming the validity of the gas law. Hitherto only a calculated value has been available for nitrogen, and the object of the present paper is to supply experimental data. Section I deals with the experimental determination of density, and Section II with refraction behaviour and dispersion. Very full experimental details are included. Section III deals with the refractive index of liquid nitrogen. Section IV evaluates the form number for the nitrogen molecule. The latter is found to behave as though its shape was approximately spherical, although it is remarkable that from dielectric considerations the spherical shape is more valid for red than for violet light. This suggests a connection with the properties of the Bohr atomic model: the electrons of the latter which are concerned in short-wave absorption being accorded larger orbits than for long-wave absorption. This, however, does not necessitate a difference for every molecule, *e.g.*, that of hydrogen, where measurements in the molecule for different orbits of the electrons remain similar. This could hardly be the case for so complicated a molecule as that of nitrogen. From the experimental data the significance of the form number for the molecular structure is made manifest. H. H. Ho.

1737. *The Temperature Coefficient of Electric Double Refraction in Liquids.* **C. Bergholm.** (Ann. d. Physik, 65. 2. pp. 128–142, May 31, 1921.)—In a previous investigation the author found that within a limited temperature range the temperature coefficients of electric double refraction in carbon disulphide, meta xylol, and brombenzol, were in agreement with the corresponding values calculated from Langevin's theory. For meta-xylol, however, the ratio between the Kerr constant at 50° C. and that at 20° was about 2 % smaller than the theoretical value. To obtain more general results the author has now investigated 10 different liquids, namely: toluol, meta-xylol, chlorbenzol, brombenzol, carbon disulphide, chloroform, ethyl ether, ethylene bromide, benzol, and carbon tetrachloride. The agreement between the observed results and those calculated on the Langevin or Born theory [see Abs. 934 (1918)] is found to be only approximate for all the liquids named. The differences from Langevin's formula are, however, very homogeneous for the various liquids. The work of Szivessy on the temperature dispersion of the electro-optical Kerr-effect for nitrobenzene between 6° and 24° C. is noticed, this result being in agreement with that calculated on the molecular orientation theory. Low-temperature measurements for toluol, ethyl ether, and carbon disulphide have also been made recently by Lyon and Wolfram, whose results therefore supplement those in the present paper. Agreement is found for carbon disulphide and toluol, but a large difference between the observed values occurred in the case of ether. The experimental arrangements are described in detail, the optical apparatus being the same as that previously used; the electrical part was, however, entirely altered. Tables of results are given, and a comparison is made with the theoretical data. Agreement is seen to be only qualitative. The ratio B_{t°/B_{20° between the Kerr constants at t° C. and 20° C. is found to be almost independent of the wave-length of the light employed for carbon disulphide and toluol. For liquids with positive Kerr constants B_p, the expression $B_{t_0} . T/(\epsilon + 2)^2$ is almost constant, ϵ being the dielectric constant. H. H. Ho.

1738. *Theory of Polarisation Prisms.* VII. **H. Schulz.** (Zeits. Instrumentenk. 41. pp. 118–121, April, and pp. 144–147, May, 1921.)—A continuation of previous work [Abs. 566 (1920), 59 (1921)]. The present paper discusses the problem of determining the magnitude of the field of view and its variations. Numerical results are given for a number of different types of prisms. A. W.

1739. *Achromatism of Centred Optical Systems.* **R. Boulouch.** (Comptes Rendus, 172, pp. 1342–1344, May 30, 1921.)—Gives a method of mathematical treatment of the problem, and describes the method of deducing the criterion for achromatism for rays of a given divergence. J. W. T. W.

1740. *Lippich's Dark Fringe and Precision Polarimetry.* **G. Bruhat** and **[Mlle.] M. Hanot.** (Comptes Rendus, 172, pp. 1340–1342, May 30, 1921.)—Describes experiments on the accuracy of polarimeters both of the Poynting and the Laurent type when Lippich's dark fringe becomes visible, and shows that it is not possible to measure a rotation of the order of 20° to an accuracy of one minute. Since the introduction of intense sources of monochromatic light has made possible a precision of the order of half a minute, it follows that the phenomenon of the dark fringe must be avoided for polarimetry of the highest precision with prisms of normal field. J. W. T. W.

1741. *New Design of Anastigmatic Flat-Field Telescope and Binoculars.* **H. D. Taylor.** (Optical Soc., Trans. 22. No. 2. pp. 63–72; Disc., 72–74, 1920–1921.)—Describes the design of a new anastigmatic flat-field telescope system of power 7 and power 10, which gives only traces of third-order aberrations in a field of 52 to 56 degrees. The system consists of four parts: (i) A doublet objective with a little inward coma to neutralise the outward coma of the eyepiece system; (ii) a quadruple negative lens consisting of two negative lenses of fluor crown cemented to and enclosing a positive of extra dense flint, and a detached negative also of fluor crown (this negative system being placed a little within the principal focal plane of the objective); (iii) a meniscus-shaped field lens of dense barium crown, and (iv) two eyepiece lenses—(*a*) a light baryta flint positive lens cemented between two meniscus negatives of extra dense flint, (*b*) a meniscus of extra dense flint cemented to a meniscus positive. The two compound lenses (*a*) and (*b*) are held together almost touching, and are moved in and out as one unit. The image produced by this system is not perfectly flat, but has a curvature of about 19 in. radius concave to the eye. It is considered that this is preferable to a perfectly flat image as the eye, when looking through binoculars, is not generally focused for infinity. The erecting system is of the form of a double prism, one prism of 60° and one of 90° being arranged base to base with their ridges in perpendicular directions. The precautions taken to ensure absence of rotation of the image as the prisms are moved are described in detail in the paper.

In reply to the *discussion*, the **Author** stated that about 40 % of the incident light is transmitted when the surfaces are freshly polished. He estimated that the cost would not be more than 50 % in excess of the cost of an ordinary prismatic binocular. J. W. T. W.

1742. *New Illustrations of Optical Theory by Ripple Motion.* **R. N. Ghosh.** (Indian Assoc. for Cultivation of Sci., Proc. 6. Parts 3 and 4. pp. 155–163, 1921.)—A specially designed apparatus for the production and stroboscopic observation of ripples consists essentially of an electromotor having at one end of its spindle an opaque disc perforated in one sector, thus allowing an illuminating beam to pass once per revolution, whilst the other end actuates a dipper producing ripples on the surface of a liquid in a glass tank. Arrangements are described by which the frequency and the amplitude of the ripples can be independently varied, the former whilst the apparatus is running. Experiments are described and discussed in relation to theory, and photographs are reproduced illustrating: (1) Interferences near caustics and the theory of the rainbow; (2) anomalous propagation near foci; (3) unsymmetrical types of laminar diffraction. A. B. C. L.

1743. *Transmission of Waves through a Symmetrical Optical Instrument.* **I. Roman.** (Phys. Rev. 18. pp. 62–77, July, 1921.)—*Gaussian Parameter Method of Studying the Transmission of a Wave Surface through a Centred System of Symmetrical Lenses.*—Since for each point of an incident wave surface there is a corresponding point on the refracting surface, the parameter β of the refracting surface may be expressed in terms of the parameter α of the wave surface, thus allowing the elimination of the parameter β. After expressing all quantities in terms of α, certain invariant combinations are found among the coefficients of the wave and lens surfaces, these furnishing the determination of the refracted surface. This gives a point-by-point correspondence between all surfaces of the system. As an application, the focal distance and longitudinal aberration are calculated and a numerical case is given. The method is applicable to aspherical surfaces as simply as to spherical ones, and it is hoped that many problems in practical optics may be simplified by the present method, combined with proper choices of the parameter. AUTHOR.

1744. *Astigmatism of Aplanatic Lenses.* **H. Harting.** (Zeits. Instrumentenk. 41. pp. 219–222, July, 1921.)—Examines the conditions for astigmatism of aplanatic lenses, namely, the class in which the aplanatic surface faces the incident light, and that in which it is turned away from the incident light. The formulæ obtained are extended to the case of a series of thin lenses of each class. J. W. T. W.

1745. *Mutual Action of Adjacent Photographic Images.* **F. E. Ross.** (Eastman Kodak Co.'s Research Lab., Comm. No. 119. Astrophys. J. 53. pp. 349–374, June, 1921.)—(1) *Stars and bright lines.*—A review of previous work shows that the results are so conflicting that general conclusions cannot be drawn. Three factors seem to control the action. The *turbidity effect* causes an attraction through optical reinforcement of adjacent sides of the images. An equation is derived from which the attraction is found to be negligible, except for very small images very close together. The *gelatine effect* causes an attraction due to the more rapid drying of the developed image. It is measured by the difference in the separation of images when wet and when dry. For normal exposures of star images less than 0·1 mm. apart the attraction is equal to about 2 μ for ordinary developers excepting pyro-metol, while in the case of lines the attraction is about 5 μ. This attraction is only slightly changed by varying the amount of sulphite or by the use of a hardener. The *developer or Kostinsky-effect* causes a repulsion as a result of the restraining effect of the products of the developing reaction, as in the Eberhard-effect. It varies somewhat with the developer, but increases with the exposure. The *variation of the total effect with exposure* is such that over-exposed images show strong repulsion due to the large developer effect, whereas normally exposed images show an attraction which usually amounts to 2 or 3 μ. To minimise the error which the effect may introduce into measurements of such images, the exposure should be as short as possible. The phenomenon is so complicated that it may be impossible to eliminate it completely. (2) In the case of *absorption lines*, both the gelatine effect and the developer effect cause a repulsion, but in addition to the attraction due to the turbidity effect there is a further attraction due to a difference in the sharpness of outer and inner edges caused by turbidity and halation. In general the total effect is an attraction, about 1 μ for normal exposures, but larger for over-exposures. Seed 30 plates were used.

Effect of Exposure on the Time of Drying of Photographic Film.—A normally exposed image dries faster than an under-exposed or an over-exposed region. AUTHOR.

1746. *New Method for the Measurement of Photographic Filter Factors.* **R. Davis.** (Bureau of Standards, Bull. 16. pp. 79–89 [Sci. Papers, No. 409], 1921. Phot. J. 61. pp. 168–175, April, 1921.)—Orthochromatic and panchromatic plates are almost always used with photographic filters to control the colour and intensity of the light falling on the photographic plates. Since the use of a filter decreases the intensity of certain colours on the plate, the photographic exposure through a filter will be greater than that required for the same plate used without a filter. A filter factor is the ratio of the exposure required with a given filter to the exposure without the filter; hence, to obtain the proper time of exposure when using the filter, the time of exposure without the filter should be multiplied by the filter factor. Heretofore filter factors have been determined by either of two methods. First, the method of trial and error; and second, the measurement, in some form of sensitometer, of plate speeds without and with the given filter. A new method is here described, whereby the filter factors for orthochromatic and panchromatic plates with various filters may be determined with apparatus using a single source of light. The energy distribution of the lamp is corrected to approximate closely that of average noon sunlight, so that the values obtained are applicable in actual practice. The test procedure is described, and an example given to illustrate the method of calculating the factor. Some of the most important precautions necessary for accurate work are enumerated. Experimental evidence is given to show that the accuracy of the instrument is distinctly greater than the uniformity of the emulsions. Suggestions as to the possible applicability of the apparatus to other problems are made. A. E. G.

1747. *Red-Sensitiveness of Silver Iodide.* **R. B. Archey.** (Phot. J. 61. pp. 235–236, May, 1921.)—The increased sensitiveness of plates bathed in soluble iodides to the red end of the spectrum, as discussed by F. F. Renwick, conforms very closely with the observations of the author during the past two years on emulsions of the kinematography positive type, of low speed and high gamma infinity. Several emulsions of this type which have normal fog values on Hurter and Driffield determinations are found in practice to be very badly fogged. It is also found that different emulsions of the same manufacture vary in the degree of fog, and that some brands of film are less sensitive to fog than others. For a measure of this fog, or sensitiveness to the red end of the spectrum, strips of various films are exposed for a period of 30 minutes to a No. 1 Wratten safelight with 25-volt Mazda bulb at a distance of 1 ft. These strips are then developed in a sensitive thermostat for a normal development, which represents a developing factor of about 1·6. The density, or log opacity of these fogged strips was measured on a Konig-Martens photometer, giving values running from density of 0·1 to 1·6. On further investigation it is found that emulsions giving low fog values, such as 0·1, vary with different batches, and that this variation is not proportional to the speed, but to the contrast of the emulsion. Tests are made of one of the films, giving the low value of 0·1 at intervals of one month over a period of 9 months. The Hurter and Driffield speed developing factor for a constant specified normal development, and the red sensitiveness were accurately determined and recorded. To illustrate the seriousness of red sensitiveness, spectrograms of two different films are given.

A. E. G.

1748. *New Theory of Photographic Phenomena.* **A. Dauvillier.** (Comptes Rendus, 171. pp. 717–719, Oct. 18, 1920.)—In a previous paper [see Abs. 1846 (1921)] the author has advanced a theory of the chemical actions produced by kathode rays, and by β, X, γ, and ultra-violet rays, the antagonistic action of light being also considered. The photographic impressions produced by these radiations can be explained in a similar manner.

A. B. W.

1749. *Further Points in the Manipulation of Impex Plates.* **L. Levy.** (Röntgen Soc., J. 17. pp. 104–106, July, 1921.)—The impex plate was first described by Baker and the author some months ago [see Abs. 1429 (1921)]. The experience gained on a practical scale has directed attention to various points and difficulties which have occurred in the usage of this plate. The object of the present paper is to indicate these difficulties, and how they can be prevented from occurring by suitable manipulation. The reduction of exposure which was claimed for the impex plate in the original paper was 25 to 1. It was soon found, however, that the ratio of reduction compared with an ordinary X-ray plate is paramountly affected by the hardness of the tube employed. From a curve given it can be seen that at an equivalent spark-gap between points of 4 in. the speed ratio is only 5 to 1, at 5 in. the ratio is 9 to 1, at 6 in. 16 to 1, at 7 in. 22 to 1, and at 10 in. it is about 35 to 1. The importance, therefore, of using a sufficiently hard tube cannot be exaggerated. Some difficulty has been found in removing the fluorescent coating on the top of the sensitive film. This has undoubtedly arisen through too low a temperature of the water used for washing off. The correct method of the removal of the impex layer is to immerse the plate in water at 110° F. In this case it will be found that the layer is completely loosened in 3 minutes, and a slight rub with a tuft of cotton wool is all that is now required to remove the last traces. Owing to the special treatment of the hardened film on the impex plate there is no risk of injury during the removal of the impex layer. Experience has shown that the use of double-strength metol hydroquinone developer is risky owing to its liability to crystallise in cold weather, thus producing numerous black spots on the plate. The following developer suggested by Baker is now recommended :—

Para-amidophenol hydrochloride	12	parts
Potassium metabisulphite	11	,,
Sodium sulphite	60	,,
Caustic soda	12	,,
Potassium bromide	1·5	,,
Water	120	,,

Dissolve the sodium sulphite, potassium metabisulphite, and caustic soda in warm water, add the para-amidophenol hydrochloride and potassium bromide, cool to 50° F., and filter. For use, this developer is diluted with six parts of water. After development the plates should be well rinsed under the tap and then fixed, preferably in an acid fixing bath. If transferred straight from the developing bath into the fixing solution there is a liability to the production of a green chemical fog. Some safe lights, particularly orange-coloured samples, transmit a considerable amount of ultra-violet radiation. This fogs the plates slightly, and the effect is to reduce the sensitiveness of the plate to X-rays. A good red light is perfectly safe, but some green ones are not. It is better to use special impex safe lights, as these can be used with all other plates as well. A. E. G.

1750. *Photochemical Observations in Polarised Light.* **F. Weigert.** (Zeits. Elektrochem. 26. pp. 357–358, Sept. 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1920.)—Linearly polarised light acts on certain sensitive layers in a specific way, different from ordinary light. The layers show dichroism and double refraction. The characteristic directions in the anisotropic systems correspond to the oscillations of the electric (e) and the magnetic (m) vectors, so that the directions of these vectors can photographically be determined. When a photochloride layer is illuminated by red, green, blue natural light, there is a selective brightening up in the respective regions, as was known. The author finds a further selective darkening in the other unexcited regions ; thus monochromatic illumination causes a shifting in the absorption. When the illumination is by linearly-polarised light, an analogous dichroitic displacement takes place, the light vibrations being more transmitted in the e direction than in the m direction ; this is the normal dichroitic effect. In the unexcited regions the effect is inverse and negative, the m predominating. These dichroitic displacements are only observable with very rapid or very faint excitations; prolonged and strong excitations lead to complex reversals, as in photographic processes [see Abs. 79 (1921)]. H. B.

1751. *Novel Magneto-Optical Effect.* **R. Whytlaw-Gray, J. B. Speakman, E[lihu] Thomson.** (Nature, 107. pp. 619–620, July 14, 1921.)—Thomson's explanation of this effect [see Abs. 1564 (1921)] is supported by experiments made by the authors on various oxides dispersed in air. The vapour of zinc ethyl diluted with CO_2 and mixed with air exhibits rapid Brownian motion under the ultramicroscope, and forms irregular chains of particles, which straighten out under the action of an electrostatic field. The particles are about 100 $\mu\mu$ in diameter. The tendency to aggregation seems weakest with the oxides of Pb, Cu, Mn, and Cr; it is slightly greater with Fe, and better with Mg, Al, Sb, and Zn oxides. The particles of CdO aggregate in strings of remarkable length.

In the second letter, Thomson considers that the chain formation may have its origin in the outer envelope of the arc flame, where the particles are formed, and are lined up round the current by the magnetic field, being afterwards broken up by gas currents. An iron arc was formed within a vertical hollow cylinder of plaster of Paris; a microscope slide was placed on the top to catch the fumes, and an electromagnet put in action across the slide. The structure of the deposit on the slide was striated, being composed of strings of brownish particles, which extended over the slide in the direction of the field. Other strings, apparently of small globules of iron of different sizes, were present; the terminal globules had tufts, which projected obliquely upward. The striated smoke layer diffuses and polarises light, but does not require the magnetic field after deposition. The optical effects may be shown by corking some fumes in a large flask; when the flask was several feet from a coil carrying an alternating current, a flickering effect was noted which kept time with the cycles, not with the alternations, of the current. G. E. A.

1752. *Magnetic Rotary Dispersion in Transparent Liquids.* **R. A. Castleman, Jr.,** and **E. O. Hulburt.** (Astrophys. J. 54. pp. 45-64, July, 1921.)—*Magnetic rotary dispersion of isotropic transparent media.* —*The electron theory* as given by H. A. Lorentz is extended, and a formula for the rotation in a range of spectrum in which electrons of only a single type, with critical frequency c/λ_1, need be considered, is developed:

$$\theta = \pi(C_1 h_1) \,.\, Hl \,.\, \frac{[1 + \sigma(\mu^2 - 1)]^2}{\mu} \,.\, \frac{\lambda_1^4 \lambda^2}{(\lambda^2 - \lambda_1^2)^2}\,;\ \text{where } C_1 h_1 = \frac{Ne^4}{2\pi^2 c m^2},$$

H is the field strength, l the length, μ the refractive index, c the velocity of light, and σ is a constant which Lorentz puts equal to about $\frac{1}{3}$ and Voigt puts equal to zero. To test this theory, substances were chosen whose dispersion was known to conform to the theory of Lorentz, and the *magnetic rotations for carbon disulphide, α-monobromnaphthalene, benzene, nitrobenzene, and ethyl iodide* for six wave-lengths from 436 to 620 $\mu\mu$ were determined with a cell 2 cm. long in a field of 6480 gauss. The angles could be measured to $\frac{1}{10}$° and were found to vary from 4° to 28°, increasing rapidly for each liquid with decreasing wave-length. Theoretical curves were computed, taking the values of C_1, λ_1, and μ from measurements by others. Below 590 $\mu\mu$ the experimental curves lie below the theoretical curves, the divergence increasing as the wave-length diminishes until the difference at 423 $\mu\mu$ is from 4 to 20 %. It is suggested that this discrepancy is due to the absorption of the violet end of the spectrum, which was neglected in the theory. The results do not decide between the values 0 and $\frac{1}{3}$ for σ. The *values of e/m for the active electrons* may be computed from h_1, and vary from 0·5 to 1·78 × 10^7 e.m. unit according to the liquid and to the value of σ assumed. AUTHORS.

1753. *Bergmann Series of Caesium.* **K. W. Meissner.** (Ann. d. Physik, 65. 4. pp. 378-392, June 28, 1921.)—Earlier work on the caesium spectrum has previously been described [Abs. 223 (1917)]. For accurate wave-length measurements of the Bergmann series lines it was essential to use a vacuum arc, since in the ordinary arc the lines are not sharp on the red side. In the vacuum arc this lack of sharpness disappears. Measurements were made of the wave-lengths of 29 lines from λ8079 to λ6010, and these include six pairs of the Bergmann series (the 5th term to the 10th). A table of these is given, and the frequency difference for each pair has the constant value 97·59 cm.$^{-1}$. Various combination series are also dealt with. [See also Abs. 433 (1921).] A. W.

1754. *Arc and Spark Spectra of the Alkalies, Alkaline Earths, and Earths; Observations with Mercury.* **R. Seeliger** and **D. Thaer.** (Ann. d. Physik, 65. 5. pp. 423–448, July 14, 1921.)—A discussion is given of the spectra of the alkalies, alkaline earths, and earths, and from this it appears that all the lines of each of these elements can be divided into two groups of smaller and greater excitation energy. The excitation energy of the arc lines of the individual elements increases from the alkalies, and through the alkaline earths to the earths. Again, for the arc lines of the same element, the excitation energy increases in the following series :—Bergmann series, principal series, second subordinate series, first subordinate series, single-line series, spark lines. Observations with *mercury* showed that in this case also the excitation energy of the single-line series is greater than that of the arc series. The spark spectrum of sodium was observed in the negative glow of the ordinary glow discharge. A photograph of this is reproduced. [See Abs. 67 (1916).] A. W.

1755. *Arc Spectra; Relative Intensity of Metallic Lines at Anode and Kathode.* **A. St. C. Dunstan** and **B. A. Wooten.** (Astrophys. J. 54. pp. 65–75, July, 1921.)—A series of experiments were performed to *test various suggested explanations* for the fact, amply verified by the authors, that metallic lines are always stronger at the kathode when the metal is introduced symmetrically. A horizontal arc enclosed in a furnace was fed with metallic vapour (Sr, Ba, Li, Cu, or Pb) supplied by an a.c. arc 5 cm. below. Water-cooling either electrode had no effect, and attempts to obtain separation of the vapours electrolytically or by electrostatic action failed. The spectrum of a 60-cycle alternating-current arc taken through a rotating sector synchronised to transmit light during only half of each cycle, was the same as that of a d.c. arc. This proves that the phenomenon is fully developed in 1/120 sec., and makes it unlikely that it is due to the transference of the vapour from one electrode to the other either thermally or electrically. When small pellets of metallic salt were dropped through the arc, the spectrum lines were fish-shaped with the heads toward the kathode. The evidence as a whole indicates that the light is due chiefly to bombardment of the metallic vapour by electrons from the kathode.

Variations with Atomic Weight.—In general the ratio of kathode to anode intensity was found to decrease as the atomic weight increased. AUTHORS.

1756. *Structure of the Bismuth Lines λλ4722, 4308, and 4122.* **H. Nagaoka** and **Y. Sugiura.** (Astrophys. J. 53. pp. 339–348, June, 1921.)—The intense light produced by bombarding bismuth with a large electronic current from a limed carbon kathode was analysed by crossing

(1) an echelon grating with a glass Lummer-Gehrcke plate, and (2) the glass Lummer-Gehrcke plate with one of quartz, to eliminate ghosts. Ten photographs thus obtained are reproduced. For the line λ4722 the 5 positive components found by previous observers were confirmed, and in addition 7 weak negative satellites were discovered, showing that the line has the same general structure as most lines of heavy metals. The principal component is probably multiple, though it has not yet been resolved. Line λ4122 has 4 strong components. Line λ4308 consists of 2 principal lines 0·350 Å. apart, each of which is a narrow doublet; in addition there are 2 faint satellites. The authors point out some constant frequency-differences common to the satellites of these lines, and suggest that they may be interpreted in terms of the quantum theory.

Fluctuations of relative intensity of the parts of the central component of the Bi line λ4722 were observed. AUTHORS.

1757. *Electric Furnace Spectrum of Scandium.* **A. S. King.** (Mt. Wilson Observat., Contrib. No. 211. Astrophys. J. 54. pp. 28–44, July, 1921. Chem. News, 123. pp. 179–180, Sept. 30, 1921.—Abstract.) —*Spectrum of Scandium in Arc and in Electric Furnace,* λ3015 *to* 6559 *A.*—A highly purified sample of scandia, prepared by W. Crookes, was placed in a graphite boat in the tube-resistance furnace operated as usual at low pressures. The relative *intensities* of 257 lines on grating spectrograms, some obtained with the furnace at a temperature of 2000, 2250, or 2600° C., and others with a carbon arc containing scandia, are recorded, together with the *classification* of each according to its behaviour in furnace and arc. About 25 lines enhanced in the arc and 150 lines enhanced in the furnace are indicated by E and A respectively. The 29 arc-flame lines are all A lines, but are scattered through temperature classes I to III; they cannot be due to oxidation, since none took place in the furnace. On the other hand, since the band lines are practically absent from furnace spectra, they are probably due to the oxide. These results are of great interest in *relation to solar and sun-spot spectra.* The A lines and low-temperature furnace lines are absent or very weak in the solar spectrum, but are prominent in the sun-spot spectrum.

Zeeman-effect for scandium lines in sun-spot spectra is large and apparently uniform. Laboratory observations are lacking at present.

Observations as to Chemical Properties of Scandium.—The scandia fused in the furnace seemed to form a carbide with the graphite boat. The shining black residue turned to a grey-brown powder after exposure to the air, presumably from the reabsorption of oxygen. AUTHORS.

1758. *Spectrum of Caesium.* **H. Bartels.** (Ann. d. Physik, 65. 2. pp. 143–166, May 31, 1921.)—Füchtbauer and Hofmann have previously made measurements of the caesium absorption lines 0·45 and 0·39 μ [Abs. 669 (1914)], and a theoretical treatment has been given by Füchtbauer [Abs. 1424 (1920)]. In the present work measurements were made on the caesium doublet (5, *p*), the wave-lengths of which are λ3612 and λ3617. For this doublet the following series law, given by Füchtbauer and Hofmann, was tested and found to hold good within the limits of error:—In the case of the doublets of the principal series of the alkalies, the absorption index at the place of max. absorption for the line of shorter wave-length is *m* times that for the line of greater wave-length, where (*m*, *p*) is the variable term of the principal series. The absorption of the line λ3612, the strong component of the above doublet, was measured and compared with that of the corresponding component of the doublet (4, *p*). By means of absorption measurements it was found possible to estimate very small vapour pressures of caesium vapour. A. W.

1759. *Absorption and Series Spectra of Lead.* **J. C. McLennan** and **R. V. Zumstein.** (Roy. Soc. Canada, Trans. 14. Ser. 3. Sect. 3. pp. 9–17, 1921.)—Experiments were made to determine if possible the absorption spectrum of non-luminous lead vapour. This was finally obtained by using a quartz tube of special design and heating it in an electric furnace provided with a coil of stout nichrome wire. Photographs are reproduced of the spectrum obtained, and a table of wave-lengths is given, with the reversals previously obtained for lead by McLennan, Young, and Ireton [Abs. 256 (1921)].

Series Spectra.—Using the above results, attempts were made to select wave-lengths which would fit into simple series formulæ of the Ritz-Rydberg type, and a principal series, two subordinate series, and a combination series were thus obtained; these are represented graphically. It appears probable that three of the wave-lengths in the spectrum of lead (λλ2203·57, 1726·2, and 1555·8) constitute members of an enhanced series of the 4N type found by Fowler for magnesium. [See Abs. 1284 (1920).] A. W.

1760. *Atomic Model and the Sharp Subordinate Series.* **E. Schrödinger.** (Zeits. f. Physik, 4. 3. pp. 347–354, 1921.)—A mathematical paper which discusses, from the standpoint of the quantum theory, the physical significance of the terms of the sharp subordinate series in relation to atomic models. A. W.

1761. *Theory of Intensity Distribution in Line Spectra.* **R. Seeliger.** (Zeits. f. Physik, 4. 3. pp. 424–432, 1921.)—The author considers that three phenomena are concerned in the intensity distribution of the coarse structure of line spectra, these three being the excitation, recombination, and the stepwise energy accumulation. These three effects, alluded to as the A-, the W-, and the S-effect, are discussed, reference being made to the work of Franck [Abs. 1172 (1920)] and others. A. W.

1762. *Ionisation of Argon by Slow Electrons.* **G. Déjardin.** (Comptes Rendus, 172. pp. 1347–1350, May 30, 1921.)—The results obtained for the ionisation potential of argon differ considerably. Thus Stead and Gossling [Abs. 298 (1921)] obtained a value of 12·5 volts, while Rentschler [Abs. 428 (1920)] found 17 volts. Using a method similar to that of Stead and Gossling the author has re-determined the ionisation potential of argon, and after making certain corrections a value is obtained of 15 volts, which is regarded as correct to within 0·5 volt. This result is in good agreement with that of Horton and Miss Davies (15·1 volts), and that of Found (between 15 and 16 volts). Calculation of the maximum frequency emitted by argon then gives a wave-length in the neighbourhood of 800 Å. It is interesting to note that Lyman has found that the spectrum of argon terminates near this limit. A. W.

1763. *Excitation of the Spectra of Argon by Slow Electrons.* **G. Déjardin.** (Comptes Rendus, 172. pp. 1482–1484, June 13, 1921.)—Stark and Kirschbaum [Abs. 1960 (1913)], in the course of their investigations on positive rays, concluded that the lines of the red spectrum of argon are emitted by monovalent ions, and that the lines of the blue spectrum are due to ions carrying two or three elementary charges. They have given a table of bivalent and trivalent lines, whose wave-lengths range from λ4000 to λ4500. The work here dealt with concerns the excitation of the spectra of argon by impact of the atoms of the gas with electrons having small velocities. The experimental arrangement employed was identical with that previously used for determining the ionisation potential of argon [see preceding Abs.]. *Red spectrum.*—Ionisation of the gas was produced with an accelerating potential of about 15 volts (the ionisation potential), but luminosity was only obtained for a potential slightly greater than 16 volts. A number of plates were obtained with voltages ranging from 16·5 to 33 volts, and these showed a great number of lines all belonging to the red spectrum of argon. A few intense lines of this spectrum appear faintly on plates taken with an accelerating potential between 15 and 16 volts, but for this an exposure of several hours is necessary. *Blue spectrum.*—The blue spectrum is only obtained when the potential is increased still further. A certain number of lines appear at about 34 volts in the region λ4300–4500, and then, towards 35 volts, in the region λ4000–4300. Almost all the lines classed as bivalent by Stark, as well as a large number of others, are visible at 35 volts. The trivalent lines (λλ4156, 4219, 4233, 4434) are only visible towards 40 volts, *i.e.*, about 5 volts greater accelerating potential than is required for the bivalent lines. The trivalent line λ4104 was visible at 35 volts, but this line is very intense, and its appearance was probably due to more rapid electrons, since the kathode beam was far from homogeneous. Some lines of the blue spectrum given in Stark and Kirschbaum's tables have not been observed; they only appear in vacuum tubes with strong condensed discharges. A. W.

1764. *Identification of Air Lines in Spark Spectra from λ5927 to λ8683.* **P. W. Merrill, F. L. Hopper, C. R. Keith.** (Mt. Wilson Observat., Contrib. No. 207. Astrophys. J. 54. pp. 76–77, July, 1921.)—*Spectrum of Condensed Spark in Air and in Oxygen, λ5927 to λ8683.*—By operating the spark alternately in oxygen and in air, the lines due to oxygen have been identified. The remaining air lines, except a few *argon* lines, are ascribed to *nitrogen*. The work confirms numerous identifications made by other observers using vacuum tubes, and adds some identifications not previously available. AUTHORS.

1765. *Measurement of Pole-Effect and its Connection with Magnetic Separation.* **H. Nagaoka.** (Astrophys. J. 53. pp. 329–338, June, 1921.)—*Method of Measuring Minute Shifts of Spectral Lines.*—By using a *displaceable slit* and by interposing an echelon or Lummer-Gehrcke plate between the source and the spectrograph, the same lines from two parts of an arc or from any two sources may be photographed side by side, and shifts of one or two milli-angstroms can be determined from the displacement of the interference points, if the lines are sharp and are not interfered with by neighbouring lines. The method could be used for the *comparison of spectra of isotopes* or for a study of the *pole-effect.* As a comparison source, the vacuum discharge from a lime kathode of carbon is recommended as both intense and free from pole-effect.

Relation of Pole-Effect to Zeeman-Effect for Iron Lines.—As Gale and

Adams have found a relation between pressure-shift and magnetic separation for lines of the same type, it might be expected that the pole-effect also varies with the Zeeman-effect; but a study of the available data shows that for positive shifts of pole-effect there is no correlation and for negative shifts the magnetic separation, if anything, seems to decrease as the amount of the shift increases. AUTHOR.

1766. *Stark-Effect of the Second Order.* **A. Sommerfeld.** (Ann. d. Physik, 65. 1. pp. 36–40, May 13, 1921.)—Takamine and Kokubu found [Abs. 1212 (1919)] that in extremely powerful electric fields the line H_γ had its central *s*-component displaced towards the side of longer wave-lengths by about 1 Å. Recent measurements of the original plate gave a result for the displacement of 0·7 Å. That this displacement should occur is evident from work by Epstein [Abs. 781 (1916)], and calculation now carried out gives for this second-order Stark-effect a value of 0·5 Å. for this particular line. The effect for H_α is much smaller (0·02 Å.), but for H_ϵ it is about 7 or 8 times greater than for H_γ. Further, it is shown that the helium lines λ4026 and λ4388 should give similar results. The agreement of the calculated displacement for H_γ with that observed by Takamine and Kokubu is sufficiently close to justify the assumption that the quantum theory of the Stark-effect is essentially correct. A. W.

1767. *Zinc Sulphide Phosphors.* **R. Tomaschek.** (Ann. d. Physik, 65. 3. pp. 189–215, June 14, 1921.)—No simple method for the preparation of zinc sulphide phosphors having been previously described, the author has evolved the following procedure: The sulphide is placed in a porcelain crucible standing in an unglazed Rose crucible, the interspace containing a few pieces of the purest sulphur. The two crucibles stand in a third, Salamander graphite crucible, and all three are covered by porcelain plates, the groove between the outermost crucible and its plate being packed with asbestos cord. The crucibles, covered by means of a porcelain lid, are heated for a suitable time in a Hempel or Merck carbon resistance furnace, and are removed while red hot from the furnace. The topmost porcelain lid is removed, a little sulphur being shaken on the plate beneath, and the whole covered with a cold porcelain lid and allowed to cool. In this way oxidation may be entirely avoided.

A number of preparations made by this method have been examined. As has been observed with the alkaline-earth phosphors, so with that of zinc, the phosphorescence diminishes to vanishing point as the purity of the materials employed increases. Addition to a highly pure zinc sulphide, giving only a scarcely perceptible drab light, of 0·000 006 gm. of copper results in a vivid fluorescence, so that the presence of a heavy metal, other than the zinc, is necessary to render the sulphide fluorescent. Phosphors obtained in the way described above are all more or less crystalline, even if they have been heated only for a short time, or at a relatively low temperature. Except when formed by sublimation, however, no regular, well-developed crystals are ever observable; under the microscope the highly phosphorescent preparations exhibit mostly a quite irregular grape-like aggregation, although isolated lustrous faces indicate clearly the crystalline character. Noteworthy is the frequent presence of bubbles within the crystals. The magnitude of the latter, independently of the duration and temperature of the heating, varies from 0·003 to 0·1 mm. The crystalline form also appears to be without influence on the phenomenon. Pure zinc sulphide crystallises below 1020° in the cubic, and at higher temperatures in the hexagonal system, yet zinc-copper and zinc-manganese phosphors exhibit the same bands with the same properties, whether prepared at 700° or at 1200°.

Influence of Impurities.—The natural colour of the phosphors containing small proportions of foreign metal is white or yellowish-white, whilst those containing more of the metal assume the colour of the sulphide of this metal. The harder of these phosphors are almost all triboluminescent, the colour of the triboluminescence corresponding with the bands appearing during the subsequent illumination, principally with those which are observed on treatment with kathode rays or in the phosphoroscope. The *influence of pressure* on zinc-copper, zinc-manganese, zinc-lead, and zinc-nickel results in the appearance of a chocolate-brown colouration and in diminution of the capacity to phosphoresce.

Zinc sulphide phosphors containing copper, manganese, bismuth, silver, lead, uranium, nickel, and cobalt have been investigated, and phosphorescence observed in several new cases, almost always at low temperatures. The results are given in detail. T. H. P.

1768. *Luminescence of Solid Solutions.* **G. C. Schmidt.** (Ann. d. Physik, 65. 3. pp. 247–256, June 14, 1921.)—It was previously (1896) found that a number of aniline dyes, which do not fluoresce when dissolved in any liquid solvent, exhibit luminescence when dispersed through certain organic substances, such as gelatine, sugar, amides, acids, etc.; that such preparations are to be regarded as solid solutions in van't Hoff's sense of the term is indicated by the observation that these dyes, when adsorbed on wool, paper, and silk, show no luminescence.

That dissolved substances behave differently as regards luminescence from adsorbed substances is now demonstrated by means of a number of dyes adsorbed by charcoal, strontium carbonate, and sulphate, silica, potassium sulphate, and uric acid. From the examination of these preparations it is stated that in no case has fluorescence been observed with a substance which is undoubtedly adsorbed. Further experiments show that when a dye is precipitated only on the surface of benzoic acid, it does not fluoresce, whereas when the dye penetrates the interior of the benzoic acid and forms with this a homogeneous mixture it exhibits fluorescence. The essential identity of fluorescence with liquids and with solids is concluded from the fact that fluorescent liquid solutions of eosin, fluorescein, etc., in fused benzoic acid, phthalic acid, benzamide, etc., retain their fluorescent properties after solidification. T. H. P.

1769. *Luminescence of Oxides Sublimed in the Electric Arc.* **E. L. Nichols** and **D. T. Wilber.** (Phys. Rev. 17. pp. 707–717, June, 1921.) —*Kathodoluminescence.*—Oxides prepared by sublimation are found to respond to excitation by kathode rays, as well as to flame excitation through a wide range of temperatures. *Upper limit of temperature.*— The temperature at which excitation ceases is in general the same, taking each band separately, for flame excitation and for kathodo-excitation. *Colour-changes.*—The shift in the colour of the luminescence is in general towards the violet with rising temperature. This shift is produced by the independent growth and decadence of overlapping bands and not to any lateral movement of the bands themselves. *Influence of pressure.*—Certain bands in the spectra of these oxides are most strongly excited by kathode rays at relatively high pressures, others appear as the vacuum becomes more complete, so that as exhaustion progresses there are marked changes in the colour of the luminescence. AUTHORS.

1770. *Flame Excitation of Luminescence.* **E. L. Nichols** and **D. T. Wilber.** (Phys. Rev. 17. pp. 453–468, April, 1921.)—*Luminescence excited by Contact with the Hydrogen Flame.*—It has been discovered that many substances may be excited to fluorescence by contact with a hydrogen flame. The conditions for this excitation are described and it is shown that this luminescence differs from photo-luminescence and also from mere temperature radiation. *Many pure oxides and sulphides* not luminescent under the action of light (notably the oxides of calcium, magnesium, silicon, aluminium, zirconium and zinc and the sulphides of zinc and calcium) and certain of the phosphorescent sulphides are shown to respond to flame excitation. *The range of temperatures* through which flame excitation occurs is perfectly definite for each substance and the upper limit is sometimes several hundred degrees above that at which photo-excitation becomes extinct.

The spectra, like those of the phosphorescent sulphides, are broad banded, and when subjected to spectro-photometric measurements they are found to consist of numerous equidistant overlapping components. These components, in the case of substances capable of photoluminescence are identical with the components of the fluorescence spectrum excited by light but are of different relative intensities. AUTHORS.

1771. *L-series of Uranium; Two New Satellites.* **A. Dauvillier.** (Comptes Rendus, 172. pp. 1350–1353, May 30, 1921.)—The paper outlines the results of a continuation of a detailed analysis of the L-series of uranium [see Abs. 1274 (1921)]. This series, photographed by very long exposures (15 hours) shows, in addition to the lines previously recorded, two new satellites $\beta_2 : \beta_2' = 754 \times 10^{-11}$ cm., and $\beta_2'' = 747$. The first of these lines was predicted by Sommerfeld. A new line $\gamma_8 = 568{\cdot}9$ has also been photographed. A. B. W.

1772. *Energy-Distribution in Continuous X-Ray Spectrum.* **A. March.** (Ann. d. Physik, 65. 5. pp. 449–460, July 14, 1921.)—The author describes an experimental investigation of the continuous X-ray spectra obtained under varying conditions. In the first series of experiments the continuous radiation is examined at constant voltage, and the following results are obtained :—

V. (kilovolts).	Total Radiation.	λ_0.	λ_{max}.
20	0·46	0·615	0·710
25	1·85	0·490	0·620
30	3·96	0·405	0·555
35	6·78	0·355	0·520
40	10·06	0·310	0·500
50	16·34	0·250	0·470

A similar investigation is then made in the case where the radiation has been filtered through varying thicknesses of different materials (Al, Zn, Cu, Fe, Ni). The results indicate that the filter affects the spectral energy-distribution in a manner similar to that produced by increase of voltage. A. B. W.

1773. *Intensity of Reflection of X-Rays by Rock-Salt.* II. **W. L. Bragg, R. W. James,** and **C. H. Bosanquet.** (Phil. Mag. 42. pp. 1–17, July, 1921.)—The object of the experiments described was to determine the amplitude of the wave diffracted in various directions by the chlorine and sodium atoms when homogeneous X-rays of unit amplitude are incident upon these atoms. The amplitude is expressed in terms of that diffracted by a single electron, the results for chlorine and sodium being indicated graphically. The following formulæ for the intensity of reflection have been used: $E\omega/I = \phi/2\mu$ for reflection at a face; $E\omega/I = \phi t_0 \sec \theta_e{}^{-\mu t_0 \sec \theta}$ for reflection at glancing angle θ through a crystal plate of thickness t_0 cut perpendicular to the reflecting planes. ϕ is given by the formula:

$$Q = \frac{N^2\lambda^3}{\sin 2\theta} F^2 \frac{e^4}{m^2c^4} \cdot \frac{1 + \cos^2 2\theta}{2 \sin 2\theta} \cdot e^{-\beta \sin^2\theta}.$$

Allowance has been made for the increase in effective coefficient of absorption μ, in the case of strong reflections, due to the existence of the "extinction-coefficient."

The amplitude of the wave diffracted by a pair of sodium and chlorine atoms is given by the factor Fe^2/mc^2. The two atoms diffract waves which are in phase with each other for all planes except those with wholly odd indices, when the waves are opposed in phase. By measuring the intensity of reflection for both types of plane, it has been possible to assign values to the amplitude diffracted by the chlorine and sodium atoms separately over a range of angles from 10° to 60°. A. B. W.

1774. *Mass Spectra of Chemical Elements.* **F. W. Aston.** (Phil. Mag. 42. pp. 140–144, July, 1921.)—The author describes a continuation of his experiments with the mass-spectrograph, the elements Se, Te, I, Sb, and Sn being submitted to positive-ray analysis. Of these elements only iodine gives definite results, its atomic weight proving to be simple and equal to 127. This is contrary to all the speculative theories of element evolution, by van den Broek, Kohlweiler, and others, which predict a complex iodine. The failure to obtain spectrograms in the cases of Sb, Te, Se, and Sn is ascribed to the very unstable nature of their compounds.

Xenon.—The author's work on xenon has been repeated with better material, with the result that the values 129, 131, 132, 134, and 136 are established as reliable for the five principal isotopes, whilst two possible additional ones, 128 and 130, have been discovered.

Chlorine.—Negative mass-spectra of chlorine have been obtained which indicate quite conclusively that 35 and 37 are the true isotopes of chlorine, whilst the lines 36 and 38 (always occurring in the ordinary mass-spectrum of chlorine) are not to any reasonable extent due to isotopes of chlorine. This result provides confirmatory evidence on the constitution of chlorine previously indicated by the author as probable.

A. B. W.

1775. *Mass Spectra and Atomic Weights.* **F. W. Aston.** (Chem. Soc. J., Trans. 119. pp. 677–687, May, 1921.)—The more important information now given has been previously abstracted from other papers.
A. B. W.

1776. *Principle of Combination and the Absorption Lines in X-Ray Spectra.* **A. Dauvillier.** (Comptes Rendus, 173. pp. 35–38, July 4, 1921.)—Since the publication of the previous note on this subject [Abs. 666 (1921)] the authors have become acquainted with the work of Smekal and Coster on the same question. The three classifications proposed are in agreement for the combination of the M- and L-series, but they disagree with respect to the series of lower frequency. The disagreement is due to an error which exists on the subject of the rays β_5 and γ_2 for tungsten and the rare earths.

The object of the present note is to make known the results of a series of complementary investigations which were suggested by the classification proposed.
A. B. W.

1777. *Anode Rays of Beryllium.* **G. P. Thomson.** (Nature, 107. p. 395, May 26, 1921.)—The method of anode-ray analysis which was used to determine the isotopes of lithium [Abs. 1213 (1921)] has recently been applied to the case of beryllium. A well-marked parabola was found corresponding to a single charge, and an atomic weight $9\cdot0 \pm 0\cdot1$ (Na = 23). No second line was observed which could with certainty be attributed to Be, but the parabola at 9·0 was not so strong as that at 7·0 for Li, and it is doubtful if one of a tenth the intensity could be observed. No indication was found which would suggest that the atom of Be can lose two electrons under the conditions of these experiments.
A. B. W.

1778. *Polarisation Phenomena in an X-Ray Bulb.* **S. Ratner.** (Nature, 107. pp. 522–523, June 23, 1921.)—The author describes this effect as follows:—Hitherto the potential difference required to produce a discharge through a well-exhausted vacuum tube has been considered to vary only with the pressure of the gas. In the course of some experiments, however, with an X-ray bulb (where the pressure could be regulated by a Gaede pump and measured by a McLeod gauge) a continuous discharge was maintained for about 8 hours on several consecutive days, and a gradual hardening was observed in spite of the maintenance of a comparatively high pressure. Further experiments carried out in this direction have revealed a remarkable effect which takes place in an X-ray bulb or, more generally, in any vacuum tube after a sufficiently long and continuous run—an effect similar to the polarisation of an electrolytic cell. After the discharge has been kept running for a sufficiently long time through a tube (inside which the pressure is kept nearly constant) a time arrives when the current flowing through the tube begins to decrease, and finally ceases altogether. To continue the discharge it is then necessary to increase either the p.d. applied to the electrodes or the pressure inside the tube. By repeating this operation several times, a stage could ultimately be reached where a p.d. of more than 50,000 volts was not sufficient to produce a discharge in the bulb, although the pressure was as high as 0·060 mm., whereas under ordinary conditions in the same bulb a much smaller p.d. was sufficient to produce a discharge under a pressure of the order of 0·001 mm. After the discharge has been stopped the bulb gradually returns to its normal condition, but afterwards a comparatively short run is sufficient to bring the bulb back to the state of polarisation.

It could be further shown that the effect is not due to changes in the nature of the gas in the bulb brought about by the discharge. A large side-tube containing two electrodes, the shape and distance apart of which were essentially the same as in the X-ray bulb, was fused into it. When after a long run the main bulb became polarised, so that the highest available voltage could not break down its resistance in spite of a high pressure of about 1/20 mm., a p.d. of 1200 volts, supplied by a battery of small cells, when put across the side-tube was found to produce a normal discharge.

Experiments, to be described elsewhere, give some evidence in support of the view that this effect is due to the destruction by the discharge, of the gaseous layer on the surface of the electrodes.

It seems probable that the hardening of an X-ray bulb with usage is due not only to the disappearance of the gas in the bulb, but also to the phenomenon described in this letter. A. B. W.

1779. *Absorption of X-Rays.* **F. K. Richtmyer.** (Phys. Rev. 18. pp. 13–30, July, 1921.)—*Measurement of absorption of X-rays.*—The use of a filtered beam of rays can at best give only approximate values of the coefficients, for such a beam is not homogeneous. It is pointed out that logarithmic absorption is no proof of homogeneity. In these experiments homogeneous radiation was secured by using a Bragg spectrometer and the effects of secondary radiation were avoided by placing the absorbing material between the two slits which limited the beam. By taking these and other precautions a precision of 1–2 % was obtained. For wave-lengths below 0·15 Å. it was found better to place the thin analysing crystal of NaCl nearly at right angles to the beam and to use the radiation reflected from atom planes perpendicular to the ones usually used.

X-ray Absorption by Ag, Al, Cu, Mo, Pb, and H_2O for Wave-Lengths about 0·13 *to* 0·7 Å.—The linear relation, established by Hull and Rice, between the ***mass-absorption coefficient*** and λ^3, $\mu/\rho = F\lambda^3 + \sigma/\rho$, holds accurately for these substances until, as λ is increased, the characteristic K limit is approached, when the values of μ/ρ are increasingly too small. The linear relation also holds above the K limit, F having a much smaller value, but σ/ρ, the ***mass-scattering coefficient***, being about the same. The ***atomic absorption coefficient*** for wave-lengths below K is a linear function of N^4, where N is the atomic number, in agreement with Owen's results. The ***general law of X-ray absorption*** is therefore as follows : $\mu_a = kN^4\lambda^3 + \sigma_a$ where k is a universal constant equal to $2 \cdot 29 \times 10^{-27}$ below the k limit and to $0 \cdot 33 \times 10^{-27}$ above that limit. The experimental curves give no evidence for the existence of the "*J*" ***radiation*** reported by certain observers for Ag, Al, Cu, and H_2O. The absorption for water was measured down to 0·093 Å., but shows no indication of an approach to the absorption found for the hard γ-rays of RaC. AUTHOR.

1780. *Quantitative Measurements of the Electron-Quantity Liberated by Canal Rays.* **H. Baerwald.** (Ann. d. Physik, 65. 2. pp. 167–188, May 31, 1921.)—Measurements on the secondary radiation from canal rays have, up to the present, been confined mainly to the determination of velocities and the velocity-distribution. An investigation is now described in which a determination is made of the number of electrons, relative to the number of primary canal rays, liberated under a variety of conditions. The method outlined in the paper is applied in the case of gases (particularly to hydrogen) and metals *in vacuo*. *For gases* the results are summarised as follows:—(*a*) The quantity of secondary radiation increases, per cm. of path, in proportion to the pressure. (*b*) The secondary radiation increases with the voltage of the primary canal rays. (*c*) The secondary radiation produced by hydrogen canal rays at atmospheric pressure approximates closely to an α-ray ionisation curve, in which the optimum of the secondary electrons is about $6 \cdot 8 \times 10^8$ cm./sec. (*d*) In the region of 0–13 mm. spark gap (*i.e.*, 0 to 31,000 volts, or 0 to $2 \cdot 5 \times 10^8$ cm./sec. linear velocity) a change from reflection to transmission occurs; at 6 mm. spark-gap (20,000 volts, or $2 \cdot 0 \times 10^8$ cm./sec. velocity) the secondary radiation is not perceptible. (*e*) The concentration of secondary electrons in the gas container is small. For a pressure of 0·1 mm. Hg the proportion of electrons to gas molecules is 1 to 200.

For metals in vacuo the amount of secondary radiation increases with the velocity of the primary canal rays towards an upper limit. This limit for hydrogen canal rays is found to be approximately 5 or 6 electrons per primary particle. A. B. W.

1781. *Application of the Ionisation Spectrometer to the Determination of the Structure of Minute Crystals.* **W. H. Bragg.** (Phys. Soc., Proc. 33. pp. 222–224; Disc., 224, June, 1921.)—It is shown that crystals in the form of powder can be examined by the ionisation method. The powder is pasted on a flat surface and placed on the spectrometer table in the position ordinarily occupied by the face of a single crystal. A bulb current of 1 milliamp. is sufficient to give satisfactory records. AUTHOR.

RADIO-ACTIVITY.

1782. *Magnetic Spectrum of β-Rays Excited by γ-Rays.* **C. D. Ellis.** (Roy. Soc., Proc. 99. pp. 261–271, June 1, 1921.)—A series of measurements has been made, by a method similar to that employed by Rutherford, Robinson and Rawlinson [see Abs. 182 (1915)], of the magnetic spectrum of the β-rays excited by the γ-rays of radium B in Ur, Pb, Pt, W, and Ba. It is shown that the main lines are formed by electrons ejected from the *k*-ring by definite γ-rays, each group of γ-rays being characterised by a certain energy. On this basis also the magnetic spectrum of the radium B β-rays is explained. The magnetic spectrum of the low-velocity β-rays of ThD has been measured and is accounted for in the same way as the radium B β-ray spectrum. On the basis of the quantum theory the wave-lengths of the γ-rays of RaB are calculated from the characteristic energies found.

Evidence is given to show that the greater the energy of binding of an electron the greater is the probability of it absorbing hard γ-radiation. A. B. W.

HEAT.

1783. *Organic Liquids for Use in Thermometers.* **G. Moeller.** (Zeits. Instrumentenk. 41. pp. 152–156, May, 1921. From the Physikal.-Techn. Reichsanstalt.)—Describes the results of experiments to determine the suitability of certain organic liquids for use as thermometric substances. The liquids were coloured with 1% of asphalt. Of the liquids tested amylbenzoate had the most even expansion, though this substance, if 0° and 100° were taken as fixed points, indicated 47·9° and 212·7° at 50° and 200° respectively. J. W. T. W.

1784. *Vapour Pressure of White Phosphorus between 44° and 150°.* **D. MacRae** and **C. C. Van Voorhis.** (Am. Chem. Soc., J. 43. pp. 547–553, March, 1921.)—Various determinations are available, but none for the range mentioned. The authors apply the method of Smith and Menzies [see Abs. 370 (1911)] keeping the temperature constant until constant pressure is observed in the isoteniscope. The empirical rule found in 4 series of experiments is $\log P = 7{\cdot}9542 - 2757{\cdot}5/T$, where P is the pressure in mm. of mercury; P rises from 0·1810 at 44° to 1·39 at 80°, 8·66 at 120°, and 27·2 at 150°. These figures are consistent with those of Centnerszwer, but are from 30 to 60 % higher than those extrapolated from Smits and Bokhorst. H. B.

1785. *Experiments on Thermal Transpiration Currents.* **G. D. West.** (Phys. Soc., Proc. 33. pp. 266–274; Disc., 274, June 15, 1921.)—This is an attempt to demonstrate the actual existence of thermal transpiration currents. Theoretical considerations are first introduced to show that if a radial temperature gradient be maintained over a disc, so that the centre is the hottest part, thermal transpiration currents sweep radially inwards over the surface of the disc, and discharge themselves more or less radially outwards in the upper regions.

To detect these currents a narrow strip of foil is used which is placed perpendicular to the disc, and to one side of the hot region. When at a considerable perpendicular distance from the disc, and when the gas pressure is sufficiently low to eliminate convection currents, the deflections of the strip of foil are always away from the hot region. When, however, the strip is placed very close to the disc, its deflections over a certain range of gas pressure are towards the hot region. These facts are explained by the tendency of the thermal transpiration currents to drag the strip with them.

The author emphasises one of the essential differences between thermal transpiration currents and convection currents—namely, that while the latter clearly depend on gravitation, the former do not. Further emphasis is laid on the differences between the conditions of molar and molecular equilibrium. AUTHOR.

1786. *Construction of Platinum-Resistance Thermometers and Immersion Heating Coils of Low Lag.* **T. S. Sligh, Jr.** (Am. Chem. Soc., J. 43.

pp. 470-475, March, 1921.)—This is an extension of a previous paper [Bureau of Standards, Bull. 6. p. 150 (1909)] and describes recent developments in the construction of calorimetric resistance thermometers. The chief modification is a simpler form of thermometer head composed of a brass shell with bakelite base and cap. The drying capsule of P_2O_5 is found to be unnecessary when the thermometer case is tight and the initial drying has been complete. With this type of thermometer very low values of δ, the constant in the Callendar formula, are sometimes obtained. This is due to strain in the wire and should be eliminated by thoroughly annealing the wire before winding the coil; by winding under *very light* tension on a mica core plate not less than 0·5 mm. thick in order to avoid the strain due to bending the wire around a sharp corner; by flash-annealing the winding both before and after placing it in the case; and by avoiding pressures on the sheath large enough to strain or deform the winding. It has been found possible to raise the δ's of thermometers from values as low as 1·44 to values as high as 1·50 by flash-annealing without opening the thermometer case. German-silver tubing is recommended for the sheath on account of its low thermal conductivity and its freedom from oxidation.

An *immersion heater* built on the same general lines is recommended for thermostated baths and for work involving the accurate measurement of heat supplied as electrical energy. E. G.

1787. *Specific Heats of Hydrogen.* **W. Rücker.** (Ann. d. Physik, 65. 5. pp. 393–422, July 14, 1921.)—Describes a new determination of the ratio of the specific heats of hydrogen, using the Kundt's tube in the form employed by Behn and Geiger [see Abs. 249 (1908)]. The mean value found was $\gamma = 1 \cdot 4053$. Using Escher's value of the specific heat at constant pressure, $c_p = 3 \cdot 4219$, the mechanical equivalent of heat is deduced as $4 \cdot 180 \times 10^7$ ergs. J. W. T. W.

1788. *Emissive Power of Gold in the Visible Spectrum.* **A. G. Worthing.** (Frank. Inst., J. 192. p. 112, July, 1921.)—Gives the results of measurements of the emissive power by comparing the brightness of the surface of an incandescent tubular filament of gold with that of its black-body interior as seen through a hole in the filament wall. A method employing comparison of brightness of a light-source with that of its image in a polished gold surface was also used. The values at $0·66\mu$, $0·53\mu$ and $0·47\mu$ were respectively found to be 0·10, 0·36, and 0·63 at room temperature, while at 1300° K. they were 0·18, 0·47, and 0·63. Thus at the wave length $0·47\mu$ there is no change in the emissive power on heating. J. W. T. W.

1789. *Colour Temperature of High-Efficiency Lamps.* **W. E. Forsythe.** (Frank. Inst., J. 192. pp. 109–110, July, 1921.)—Gives the results obtained by colour-matching various types of lamps with a black body, using a Lummer-Brodhun contrast head. For the Mazda C lamps the standards of colour were obtained by pyrometer measurements of the relative brightness in limited parts of the red and blue ends of the spectrum for both the colour standard and the black body, assuming that the two sources were at the same temperature when they had the same ratio of red- to blue-brightness. The true temperatures were obtained by pyrometer on the middle part of the filament using, $c_2 = 14{,}350\ \mu$ degrees and the gold point 1336° K.

Lamp.	Watts/M.S.C.	True Temp. (° K).	Colour Temp.
50-watt Carbon	3·76	2115	2156
50-watt Gem	3·1	2180	2195
50-watt Tantalum	2·56	2160	2260
40-watt Mazda B	1·36	2410	2460
100-watt Mazda C	1·00	2745	2740
500-watt Mazda C	0·72	2835	2880
1000-watt Mazda C	0·62	3010	2985
1000-watt Stereopticon	0·52	3185	3175
900-watt Movie	0·46	3290	3220

J. W. T. W.

1790. *Calculation of the Specific Heats of Gases.* **W. Herz.** (Zeits. Elektrochem. 27. p. 125, March, 1921.)—Since the difference between the two specific heats per mol. of a gas is equal to the gas-constant R in thermal units, that is, to 1·985 cal., and since also M for non-associated liquids is related to the critical volume and density in accordance with the expression, $M = d_k v_k / 0{\cdot}0000439$, it follows that $c_p - c_v = 0{\cdot}000087/d_k v_k$ . . . (I). Further, the fact that, for such liquids, $L = 0{\cdot}00093\ T_s/d_k v_k$, where T_s is the boiling-point and L the heat of evaporation, leads to the relation, $c_p - c_v = 0{\cdot}0935\ L/T_s$ . . . (II). Again, as $L = p_k T_s / T_k d_k$, equation (II) becomes

$$c_p - c_v = 0{\cdot}0935\ p_k/T_k d_k \ . \ . \ . \ \text{(III)}.$$

The values of $(c_p - c_v)$ are calculated from these three expressions for a number of non-associated substances. T. H. P.

1791. *Molecular Movements and the Laws of Heat Radiation.* **L. Brillouin.** (J. de Physique et le Radium, 2. pp. 142–155, May, 1921.)—Einstein and Hopf [Abs. 539 (1911)] have studied the movements of a doublet exposed to radiation, on the assumption that they were due to the irregular impulses caused by fluctuations of the radiation, due to interference. They concluded that to account for the facts, on this basis, it was necessary to assume Rayleigh's radiation law, which, however, is contradicted by experiment. Einstein, about the same time, had shown how to calculate the fluctuations of energy thermodynamically [Abs. 909 (1909)], and the present author has already developed these ideas [Abs. 1575 (1921)]. Finally Einstein has treated the case of a Bohr atom, stated the laws of probability for the absorption or emission of a quantum and, using Planck's law of radiation, showed that the molecule moves as required.

A Brownian movement requires, first, a viscous resistance, and secondly, irregular impulses due to fluctuations in the surrounding medium. The resistance is due to the fact proved by Einstein that, in the case of a particle which is *moving* in a space uniformly filled with isothermal radiation, it is not true that the density of radiant energy on all sides of the particle is the same. When it absorbs the radiations the radiation-pressures do not balance one another, and a resultant is left proportional to the velocity of the particle, and in the opposite direction. In other words, the particle behaves as though it were in a viscous medium.

Three cases are considered; the first that of a small absorbing sphere. This may be completely absorbing during certain intervals of time and incapable of absorbing at other times. The mean values of the energy absorbed by the sphere in time τ from different directions are equal to one another, but there are constant small deviations from this mean, and these produce impulses in different directions at different times, but so that the mean squares of the impulses along the three axes X, Y, and Z are equal to one another. A formula is obtained for these impulses, due to fluctuations in the radiation absorbed, and it is shown that the amount calculated must be doubled in order to take into account the fluctuations in the emission of the radiant energy. Combining these impulses with the viscous resistance discussed above it is found that the result agrees with Wien's law of radiation. No special hypothesis is used as to the mechanism of absorption or emission, the fluctuations being calculated indirectly by means of the probability method.

The case of a small sphere which has a coefficient of absorption less than unity is then considered. There are now three causes for the fluctuation impulses, *i.e.*, namely: fluctuations in the energy of the incident radiation, fluctuations in the proportion absorbed, fluctuations in the emission. It is supposed that the coefficient of absorption is not really constant, but varies about a mean value. Taking all these different fluctuations into account, as in the previous case, it is found that the result agrees with Wien's law here also. Finally the case of a small reflecting sphere is considered. There is now no question either of absorption or emission, and everything depends on the properties of the electromagnetic ether, that is to say on the constant variations in the energy density of the radiations on either side of the mean, according to the probability law. The mean square of the impulses in any direction is calculated as before, and combining this with the viscous resistance Wien's formula is arrived at. It is not possible by this method to arrive at a formula for the radiation of a black body, since nothing is postulated as to the mechanism of radiation. Another important point is that it is necessary to suppose that the emission of the radiation is directed. This leads to difficulties when the particle considered is an atom or a molecule, and it is for this reason that spheres of such a size that the ordinary laws of optics can be applied to them are considered in the paper. The results obtained are probably true for the more complicated cases from a mathematical point of view, which would arise if molecules and atoms were considered. H. N. A.

1792. *Forces arising from Illumination of Blackened Surfaces.* **H. Sirk.** (Zeits. f. Physik, 4. 2. pp. 211–220, 1921.)—When a surface is exposed to radiation, previous researches have shown the existence of two forces—a radiation-pressure and the radiometer effect. Experiments described in the present paper, which were carried out under conditions which precluded the occurrence of both the above forces, showed the existence of a third force, which has a component in the direction of the surface. In the case of radiation incident obliquely, it changes sign

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with change of sign of the angle of incidence, and appears under certain suitable conditions to simulate a radiation-pressure. A. W.

1793. *Radiometer Measurements.* III. **W. H. Westphal.** (Zeits. f. Physik, 4. 2. pp. 221–225, 1921.)—A continuation of earlier work [Abs. 589 (1920) and 97 (1921)]. The present paper describes experiments with radiometers having quartz fibres of 8 to 10 cm. length hanging in a vertical tube. The lower ends of the fibres were illuminated by the light from a Nernst lamp. In one type of radiometer the vertical tube was sealed into a horizontal tube 0·8 cm. internal diam., one end of which was closed by a plane-parallel glass plate, through which the end of the fibre could be observed. In another type the vertical tube was sealed into a rectangular vessel, one side being formed by a plane glass plate, and the opposite side by a matt glass plate which was faintly illuminated by a lamp with a water filter interposed. The "radiometer function" was found to be symmetrical in all the gases dealt with in the pressure region investigated in the previous work with the vane type of radiometer. A typical curve is given for a fibre of 0·0025 cm. thickness observed in an atmosphere of hydrogen. The maximum effect, which for the vane radiometer occurs at about 0·02 mm. pressure, was found for the fibre radiometer to be shifted appreciably towards higher pressures. The position of the maximum is dependent on the thickness of the quartz fibre, the dimensions of the chamber, and the nature of the contained gas, as is shown by a table of results for hydrogen, air, and CO_2. The behaviour of the radiometer function was concordant for all the measurements. A comparison with previous results for the vane type shows that for the quartz fibres the curve is somewhat flatter. The results are briefly discussed with reference to the work of Rubinowicz [Abs. 1616 (1920)], Ehrenhaft and Parankiewicz [Abs. 1085 (1918) and 425 (1919)], and of Laski and Zerner [Abs. 1107 (1921)]. A. W.

1794. *Spherical Waves Produced by Sudden Explosion of a Detonating Gas within a Spherical Envelope.* **S. Banerji.** (Calcutta Math. Soc., Bull. 12. pp. 1–4, June, 1921.)—The author has shown in a previous paper [Calcutta Math. Soc., Bull. 11. p. 83 (1920)] that the velocity of propagation of spherical waves of finite amplitude is $[1/\rho \, . \, dp/d \log \rho r^2]^{1/2} + q$, where q denotes the particle velocity, r the radius vector from the source of disturbance, p the pressure and ρ the density.

This paper shows that the impulsive pressure P at any point can be obtained from the equation $P = \pi / \left\{ 2c\sqrt{(\pi t)} \right\} 3 \, . \, e^{-r^2/4c^2t}$ if the gas obeys Boyle's law and $P = c^2\rho$, π being the sudden pressure produced by an explosion within a sphere $r = a$. Introducing this expression for P into that for the velocity of propagation, the velocity of the explosion waves at any point can be obtained. The author intends to verify his results when suitable experimental data are available. H. N. A.

1795. *Effect of the Planck Oscillators on the Spectral Energy Distribution of the Radiation Field.* **E. Kretschmann.** (Ann. d. Physik, 65. 4. pp. 310–334, June 28, 1921. Extract from Habilitations Thesis, Königsberg.)—In view of the extraordinary success of the Bohr atomic model for the explanation of radiation phenomena, the author thinks the present investigation of the classical model of an electromagnetic oscillator, with a charge element having a quasi-elastic union, *i.e.*, a Planck oscillator, may at first sight, perhaps, seem unreasonable. But the employment of the continuously emitting and absorbing Planck oscillator affords a representation of a source of monochromatic electromagnetic radiation without essential changes of the mathematical laws. On the other hand, the Bohr theory is vague with respect to details of the special emission and absorption procedure, while the numerous results derived from the Bohr model are as yet inexplicable from a general standpoint. Section 1 considers the motion of the oscillator in the radiation field, and a new form of the integral of the oscillator equation is derived. Section 2 gives a simplified determination of the idea of natural oscillation from an investigation of the energy balance of the oscillator. Section 3 deals with the absorption and emission intensity of the special frequency of the oscillator for the cases of impact waves with actual and potential interference, and of stationary natural radiation of any desired form. For the latter it is shown in Section 4 that every oscillator increases the radiation intensity of its special frequency at the expense of the remaining radiation, to the extent that the radiation intensity is directly, and the frequency of the oscillator inversely, proportional to it. In the final section the relationships of the results are discussed with respect to the Planck energy-distribution law and Wien displacement hypothesis, the Kirchhoff law, and the second law of thermodynamics.

H. H. Ho.

1796. *On the Statement of the Principle of Equivalence.* **L. Décombe.** (Comptes Rendus, 172. pp. 1479–1481, June 13, 1921.)—A recent note by Leduc (*ibid.*, p. 1167) has drawn attention to the rôle of reversibility in the application of the principle of equivalence. The present author now shows that by introducing the idea of reversibility into the statement of the principle, two distinct principles may be evolved whose separate application enables a more exhaustive analysis of calorific phenomena to be made. The principle of equivalence is expressed by $dw + du = \mathrm{T} + \mathrm{JQ}$, where dw represents the variation of kinetic energy of the system, du the variation of internal energy, T the work effected by the external forces, and Q the heat absorbed. A reversible transformation giving rise to the same variation of internal energy du, involves the active force of the system to be constantly zero, making $dw = 0$, that is, $du = \mathrm{T}_c + \mathrm{J}\phi_c$, where T_c is the work of the forces necessary for securing mechanical equilibrium at each instant, and ϕ_c the heat effect for the calorific equilibrium. Since $\mathrm{T} = \mathrm{T}_c + \mathrm{T}_n$, and $\phi = \phi_c + \phi_n$, where T_n and ϕ_n are the uncompensated work and heat respectively, therefore $dw = \mathrm{T}_n + \mathrm{J}\phi_n$. The primary relation thus divides itself into two others which are entirely distinct; the first contains only the reversible elements of the transformation, and conditions the variation of internal energy being completely independent of the speed of the phenomenon; the second involves only the non-reversible elements, and conditions the variation of kinetic energy, depending directly on the speed of the transformation. It is important to note that the second relation is always rigorously applicable to the reversible part of any real transformation whatever, and its neglect has given rise to confusion in the work of many previous investigators. This division of the principle of equivalence requires a revised statement, namely: There is always equivalence between the loss of active force of the system relative to the corresponding purely mechanical transformation and the heat evolved by the system. Several special cases are considered. H. H. Ho.

1797. *Thermodynamic Laws and Reversibility.* **A. Leduc.** (Comptes Rendus, 172. pp. 1018–1020, April 25, 1921.)—The validity of applications of both the first and second laws of thermodynamics frequently implies reversibility of the systems to which they are applied, and capable physicists have fallen into serious error. When the statement is made that the entropy differential is a perfect differential it is on the basis of the application of the second law to a reversible system. But this does not warrant the statement, sometimes made, that to apply the second law to a system and to express its reversibility are one and the same. The author discusses Edlund's attempts to determine experimentally the mechanical equivalent of heat by measuring the heat developed in a vertical wire by the application of a weight [Ann. Chim. Phys. (4th Ser.) 8. p. 257 (1866)]. Its main interest now is as a warning to apply the first law to a complete cycle only. G. W. de T.

1798. *A Physical Interpretation of the Energy Quantum.* **I. Aucken.** (Nature, 107. p. 553, June 30, 1921.)—It is suggested that the amplitude of a periodic disturbance in the ether can alter only by definite amounts depending on its frequency, so that, as soon as any part of a wave-front meets with something capable of inducing a decrease in amplitude, *e.g.*, a suitably situated electron, that part suffers a definite decrease of amplitude, which extends back into the wave-train to the extent of one quantum. Ether is relieved of its energy of strain, not continuously, but in quanta. It is suggested that with the above modification the wave theory renders understandable phenomena such as interference and the photoelectric effect. A. B. C. L.

1799. *Mechanical Definition of the Liquid and Gaseous States.* **F. J. de Wisniewski.** (Arch. des Sciences, 3. pp. 256–261, May–June, 1921.)—The present paper contains an attempt to derive a kinetic theory of gases and liquids, which sets out clearly the distinction between the liquid and gaseous states and at the same time defines the critical state. The essential feature lies in the hypothesis that a gas or liquid is constituted of molecules which attract each other with a certain force and move conformably to rational mechanical laws. The paper itself is mathematical [easy] throughout, and it is shown very simply why the liquid state has always finite dimensions, while a gas always tends to increase its volume. H. H. Ho.

1800. *Saturation Pressures of Certain Vapours between* + 10° *and* − 181°. **F. Henning** and **A. Stock.** (Zeits. f. Physik, 4. 2. pp. 226–240, 1921. From the Physikal-Techn. Reichsanstalt.)—This paper contains an account of the experimental determination of the saturation pressures of several vapours in the region between + 10° and − 181°, made according to the static method and on the temperature scale of the Reichsanstalt [see Abs. 1169 (1913)]. The chemical preparation of the different substances, as well as the filling of the vapour-pressure tube, was carried out in the Kaiser-Wilhelm Institute for Chemistry. Section 2 of the paper deals with the chemistry of the investigation. The respective vapours were fractionally distilled under reduced pressure until no changes in vapour tension could be detected. The following substances were employed :—CS_2, SO_2, NH_3, CO_2, HCl, PH_3, C_2H_4, and CH_4, and their mode of preparation and purification is briefly described. The greater part of the paper, however, is devoted to the experimental details, and the results are assembled in 8 tables. For each substance the Nernst formula, $\log p = -b/T + 1{\cdot}75 \log T - cT + a$, is derived and the three constants a, b, c are calculated. The last section of the paper contains a comparison with the earlier data. H. H. Ho.

1801. *An Equation of State for Nitrogen at Great Densities.* **R. Becker.** (Zeits. f. Physik, 4. 3. pp. 393–409, 1921.)—The paper commences with a discussion of recent work on the modification of van der Waals' equation, in which the basic assumption appears to be that gas density is not very great and that any one molecule can only interact simultaneously with a few others at any particular instant. Empirical formulæ have been proposed to meet the experimental data without regard to theoretical considerations. Chief among these is a power series formula by K. Onnes, namely: $p = A/v + B/v^2 + C/v^3$, in which the separate virial coefficients A, B, C are determined from measurements to be functions of the temperature. In certain applications, as in ballistics and in explosive investigations, there is greatly needed an equation of state which holds valid in the region of extremely high pressures. An equation of the above form with about 8 virial coefficients has been established by K. Onnes and Walstra for hydrogen. This holds good at room temperatures up to 3000 atmos., but is extremely involved and laborious in practice, and moreover requires bold extrapolations. It is obvious with such an equation and a convenient number of coefficients that any particular set of measurements can be accounted for, but the probability that such a power series, involving wide extrapolations, will render correct values generally is not so great as for the case of other functions which involve only one or very few constants.

In the present paper an equation of state has been derived for nitrogen to meet practical requirements, and is based on Amagat's data on the 0 and 15° isotherms between 0 and 3000 atmos. It has been found valid in the case of explosives where pressures of 100,000 atmos. were attained, and in addition has furnished useful low-temperature data for the critical constants of liquid nitrogen. The application of the equation of state to solid bodies has also furnished further evidence of its general validity. Section 1 of the paper deals with the new equation of state, which is found to be, $p = R\,.\,T1/v\,.\,(1 + k/v\,.\,e^{k/v}) - a/v^2 + k/v^{\beta+2}$. When this equation refers to a gramme molecule of nitrogen, the constants are $R = 8{\cdot}31 \times 10^7$, $k = 40{\cdot}3$, $a = 1{\cdot}26 \times 10^{12}$, $x = 384 \times 10^{17}$, $\beta = 5$.

Section 2 deals with the critical data, and Section 3 with the repulsive force between the nitrogen molecules concluding with a discussion of the molecular structure. A repulsion law is derived for the nitrogen molecule and compared with the laws of Mie and Grüneisen for metals and of Born and Landé for the crystal lattice. The paper is mathematical throughout. H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

1802. *Electron Field on Einstein's Gravitation Theory.* **G. B. Jeffery.** (Roy. Soc., Proc. 99. pp. 123–134, May 2, 1921.)—The established consequences of Einstein's Gravitation Theory so far are obtained from solution of the equations corresponding to a single isolated singularity. Exact solutions corresponding to two isolated singularities are urgently required for further explanation of the theory; the approximate solutions of de Sitter, Dröste and Einstein, though valuable in default of exact solutions, may mislead and perhaps exclude effects of such importance as radiation. Meanwhile the author examines the theory with relation to atomic phenomena, where separation between gravitation and electricity does not appear legitimate. Here, free from averaging, mass and charge seem inextricably connected, existing in definite proportions, perhaps only as electrons and H-nuclei. Nordström has investigated the gravitation field corresponding to such a charged particle by variation of the Hamiltonian function of the combined fields [Abs. 1019 (1918)], resulting in the equation of the line element of space surrounding a singularity of both the gravitational and electric fields $ds^2 = - \gamma^{-1}dr^2 - r^2d\theta^2 - r^2 \sin^2 \theta d\phi^2 + \gamma c^2 dt^2$, where $\gamma \equiv 1 - 2\kappa m/c^2r + \kappa\epsilon^2/4\pi c^4r^2$; here c is the speed of light, κ the gravitation constant and m is a constant of integration subsequently seen to be the mass. The gravitational field is defined by the symmetrical covariant tensor $g_{\mu\nu}$, and the electromagnetic field by the covariant vector $\kappa_\mu \equiv (-\mathrm{F}, -\mathrm{G}, -\mathrm{H}, \Phi)$, where F, G, H are the vector potential components and Φ is the scalar potential. For a symmetrical static field, Schwarzschild's equation is assumed in the form $ds^2 = - e^{\lambda}dr^2 - r^2d\theta^2 - r^2 \sin^2 \theta d\phi^2 + \epsilon^{\nu}d\tau^2$, λ and ν being functions of r only. Then it is found that if the gravitational field vanishes at a great distance from the origin $\kappa_4 = \epsilon/4\pi r$, where ϵ is a constant afterwards identified with the electric charge in Lorentz units, and such that $\epsilon^{\nu} = \gamma$.

The author gives his own derivation of Nordström's equation, arrived at independently by a more direct application of Einstein's methods. In default of the solution corresponding to two singularities, a good approximation to the motion of an electron in the neighbourhood of an atomic nucleus is obtained by assuming the mass and charge of the former so small as to leave the field unaffected by the motion. The equations of motion in the absence of a gravitational field are established, and, being of the tensor form, will, on the equivalence hypothesis, be true for any coordinate system and in the gravitational field. The resulting orbital equation shows that r is expressible as an elliptic function of ϕ of real period, so that r is a periodic function of ϕ, though the period will not in general be 2π, so that the orbit will not be closed, and there will be rotation of the apse lines. A more complete solution, including the effects of both particles, would probably lead to aperiodic orbits, which would correspond to Einstein's conclusions that moving masses imply radiation of gravitational energy, from which he infers that his theory must be subject to the restrictions of the Quantum theory. But the author suggests, as a possible alternative, that the complete solution of the problem of two bodies might well lead to orbits not in general periodic, but which *may* in certain circumstances be periodic, giving the "quantised" orbits. If it should then appear that the aperiodic orbits tended asymptotically to periodic orbits, the whole secret of the Quantum hypothesis would be laid bare. As in classical electromagnetic theory a point singularity is excluded as involving infinite mass, so in Einstein's theory it is excluded when the effect of electric charge is neglected, and we have a solution with a point singularity surrounded by a spherical surface of singularity. But, including the effects of charge, it appears from the analysis that γ has no zeros of infinities other than $r = 0$, if $\epsilon^2/m^2 > \kappa$, *i.e.*, $> 0 \cdot 67 \times 10^{-7}$ C.G.S. unit, a condition amply satisfied both for the electron and the H-nucleus, which may therefore be regarded as true point singularities of the field. Approaching such a point, γ becomes very great and the field profoundly modified. The radius of a sphere on the surface of which the g's have the same value as at infinity may be taken as measure of this region, and is the radius of the electron as here calculated. It is of the accepted order of magnitude. Further analysis shows that for large values of p the deflection of a light-ray passing near an electron will be $4\kappa m/c^2p - 3\pi\kappa\epsilon^2/4c^4p^2$, where p is the length of the perpendicular from the origin to the asymptotes of the path of the ray. The first is the Einstein deflection, and the second term shows that it is reduced by the electric field. For small values of p it is shown that as it diminishes the deflection increases to a maximum and then decreases, becomes negative, and finally approaches $-\pi$, so that the ray is returned very nearly along its original direction. In the case of a light-ray passing near the sun, it is found that for the reduction to zero of the Einstein deflection by the sun's electric field a potential gradient of the order of 10^{13} volts per cm. would be required, which is far too high to be admissible, and it is easily seen for any possible value of the sun's electric field, the second term will that, be so small compared to the first as to exert no measurable effect on the bending of the ray in the sun's gravitational field.

O. J. Lodge. (Nature, 107. p. 392, May 26, 1921.)—Introducing the dielectric constant of the ether into the Nordström-Jeffery expression for γ, and making use of J. J. Thomson's (1881) expression for the inertia of an electric charge, $m = 2\mu e^2/3a$—which is reasonable, inasmuch as the gravitation constant is dominant over both the second and third terms—we have $\gamma = 1 - 2Gm(1 - 3a/4r)/rc^2$. This is minimum when $r = 3a/2$, and is unity at infinity and when $r = 5a/4$. This last probably means that the electric and mass terms just balance at the surface of an electron (for we may probably ignore the $\frac{3}{4}$ factor as unlikely to be accurate so close to a charge), or else it means that the gravitational effect at an electron boundary is reduced to $\frac{1}{4}$ of its normal value. The new term is not merely the natural consequence of electromagnetic mass, for it is opposed in sign. Although the third term is of no astronomical significance, it is of great importance as a contribution to the behaviour of a stream of radiation at its absorption end, when it impinges on, or penetrates between, the ultimate elements of matter, hitherto neglected in comparison with that of the emission end. By the two together we may hope ultimately to obtain some information as to the structure of an electron. It must be emphasised that the e^2, above, means the square of the unbalanced charge only—it is $(\Sigma e)^2$ not $\Sigma(e^2)$—and that all neutralised charges are provided for by the second term. The conclusion that unbalanced electric potential and neutralised or mass potential oppose each other in their

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warping effect on the ether appears rather suggestive. The author would have expected a third term which did not involve the gravitation constant, and suggests that " perhaps there may be a reconsideration on this point, for the present manner of obtaining the expression is far from easy—in fact, is abstruse." G. W. de T.

DISCHARGE AND OSCILLATIONS.

1803. *Measurement of Mobility of Gaseous Ions by the Toothed-Wheel Method.* **Laporte.** (Comptes Rendus, 172. pp. 1028–1030, April 25, 1921.)—The method employed by the author for measuring ionic mobilities is analogous to the toothed-wheel experiment of Fizeau for measuring the velocity of light. The measurements, however, do not lay claim to great accuracy, and the results are given only as indicating the possibilities and novelty of the method. A. B. W.

1804. *Theory of the Motion of Electrons between Coaxial Cylinders, taking into account the Variation of Mass with Velocity.* **L. Page.** (Phys. Rev. 18. pp. 58–61, July, 1921.)—*Motion of Electrons between Coaxial Cylinders, the Electric Field being Radial, the Magnetic Longitudinal.*—If in Hull's coaxial cylinder method of measuring e/m, large potential differences are used, it is necessary *to take account of the variation of mass with velocity.* Putting the expressions for transverse and longitudinal mass into the equations of motion and integrating, we get : $e_0/m_0 = 8\pi^2c^2R^2V/(N^2 - 4\pi^2R^2V^2)$, which depends only on the larger radius R, the total magnetic flux N, and the total potential drop V, and is not affected by space charge. Because the longitudinal mass is involved, this equation provides a *method of experimentally verifying the theoretical expression for longitudinal mass.* Author.

1805. *Mobilities of Ions in Helium at High Pressure.* **J. C. McLennan** and **E. Evans.** (Roy. Soc. Canada, Trans. 14. Ser. 3. Sect. 3. pp. 19–26, 1921.)—Experiments with helium at pressures of about 80 atmos. showed that the gas does not exhibit any conductivity other than that which might be due to ionisation by the earth's penetrating radiation. The mobilities of positive and negative ions produced in helium at a pressure of 81 atmos. by α-rays from polonium were found to be respectively $2\cdot52 \times 10^{-2}$ and $4\cdot26 \times 10^{-2}$ cm. per sec. per volt per cm. It was also found that the mobilities do not vary inversely with the pressure at high pressures. The method employed was the same as that adopted by McLennan and Keys [Abs. 1727 (1915)] in measuring the mobilities of ions in air at high pressures. A. W.

1806. *Critical Electron Velocities for the Production of Luminosity in Atmospheric Neon.* **F. Horton** and **[Miss] A. C. Davies.** (Phil. Mag. 41. pp. 921–940, June, 1921.)—The authors have recently shown [Abs. 127 and 294 (1921)] that in neon there are two critical electron velocities associated with the production of radiation from the gas, and three associated with the production of ionisation. The experiments described in the present paper lead to the conclusion that there is no luminosity produced in neon as a result of the first type of ionisation, beginning at 16·7 volts. This absence of luminosity at 16·7 volts suggests that the corresponding spectrum may consist entirely of lines outside the visible region. It is also shown that the lines contained in the spectrum of the glow when first produced, at 20 volts, are all of the principal series (1·5, $s - m, p$) type according to Paschen's classification; while the lines which do not appear until the ionising velocity 22·8 volts has been reached, are all of the (2, $p - m, s$) and (2, $p - m, d$), or subordinate series types. A discussion of these results with reference to the Bohr-Sommerfeld theory, leads to the conclusion that the different ionisation velocities which have been detected correspond to the removal of differently situated electrons from the neon atom, and hence that lines as closely related as those of a principal and the corresponding subordinate series arise from the return of electrons removed from different positions within the atom. The results obtained lead to conclusions in contradiction to the theory of Lewis and Langmuir in its present form, but modification of the theory might remove the differences. A. W.

1807. *Effect of a Uniform Magnetic Field on the Motion of Electrons between Coaxial Cylinders.* **A. W. Hull.** (Phys. Rev. 18. pp. 31–57, July, 1921.)—*Equations of motion for electrons* are developed starting from a cylindrical kathode and moving toward a coaxial cylindrical anode, in a uniform magnetic field parallel to the common axis. The electrons will reach the anode if the ratio of potential difference to magnetic field is greater than a critical value, and will fail to reach it if the ratio is less than this value. In the case of a *small kathode* in the axis of an anode of radius R at potential V, the critical magnetic field is $H = (8m/e)^{1/2}V^{1/2}/R$. For a *small anode* of radius r_0 at potential V, in the axis of a kathode of radius R_0, the critical field is

$$H = r_0/R_0 \,.\, (8m/e)^{1/2}V^{1/2}/R_0 + 2mv_0/eR_0.$$

In this case the initial velocity v_0 of the electrons cannot be neglected. This equation also applies, with appropriate R_0 and e/m, to *positive ions* produced by electrons from an *internal kathode*. If the radii of *both cylinders are large* the solution reduces to the familiar one of plane parallel plates.

The *equation of the path* of the electrons is deduced, on the assumption that the space charge distribution is the same as without magnetic field. The path is given by $r = R\,(\sin\tfrac{2}{3}\,\theta)^{3/2}$. This is a close approximation to the true path, as calculated from the space charge distribution recently worked out by Langmuir. Experimental curves showing current at constant potential as a function of magnetic field, for different anode diameters, voltages, filament temperatures, degrees of symmetry, etc., are in agreement with theory within the limit of experimental error.

The *internal kathode* tube offers a means of measuring e/m, and the *internal anode* a means of measuring the distribution of initial velocities. AUTHOR.

1808. *Effect of an Electric Current on the Photoelectric Effect.* **A. G. Shenstone.** (Phil. Mag. 41. pp. 916–921, June, 1921.)—During experiments to determine whether there was any relation between the Hall-effect in bismuth and the photoelectric effect, it was found that the total photoelectric current was so much influenced by the current passing through the bismuth that the original experiments had to be abandoned. An investigation was made of this new effect, and it was found that for any given crystal plate current the photoelectric current increased up to a maximum, beyond which it did not go unless a larger plate current was used. With very high currents this maximum was followed by a fairly rapid decrease in the photoelectric current. The rises of the photoelectric current were always very slow, in some cases taking two hours to attain the maximum. When the plate current was stopped, the photoelectric current at once started to decrease, at first quite rapidly; but apparently it never drops exactly to the original zero, usually going beyond it. Curves are given showing the relation between the maximum photoelectric current and the plate current, both for a crystalline plate of bismuth and for a sputtered film. The latter, whether thick or thin, gave results similar to the crystalline plates, except that the sputtered films were always consistent and could be run up to the point at which the films burned out. The crystalline plates could only be used once without inconsistencies appearing. It appears probable that the effect is to be explained as being due to an orientation of the elementary crystals of the metal. A. W.

1809. *Moving Striations in a Neon Tube.* **T. Kikuchi.** (Roy. Soc., Proc. 99. pp. 257–261, June 1, 1921.)—A continuation of former work [Abs. 128 (1921)]. In the earlier work the discharge tube was excited by an induction coil, but in the present experiments direct current was employed; otherwise the arrangements were similar. Three types of moving striations are described and the relations between them briefly discussed; the effects of a magnetic field and of temperature are also dealt with. A. W.

1810. *The Figures of de Heen and the Electric Discharge.* **A. Lafay.** (Comptes Rendus, 173. pp. 32–34, July 4, 1921.)—M. de Heen has shown, many years ago, that a layer of electrified resin placed for some moments under a certain number of flames or points acquires the property of covering itself with characteristic designs when a light powder is thrown upon it. These designs are produced by electrified particles emitted by the flames or points under the action of the electric field. This phenomenon can be produced more easily by placing a slab of non-electrified resin upon the lower armature of a plane horizontal condenser, the other armature of which is pierced with some small holes to receive the necessary points. The charges carried by the field become fixed on the resin and their distribution is revealed by sprinkling the slab with a mixture of sulphur and minium. By withdrawing the points at very short and progressively increasing intervals, starting from the instant when the field is established, it is possible to follow the evolution of the phenomenon, and to establish that at right angles to each point an electrified spot is formed, which is at first very small and circular, then increasing and at the same time becoming deformed by the apparent influence of the neighbouring spots.

A second experiment for separating the different effects which occur in the formation of these figures is also described. A. E. G.

1811. *Direct Measurement of the Mobilities of Electrified Particles in Gases; Use of the Method in Anemometry.* **A. Lafay.** (Comptes Rendus, 173. pp. 75–76, July 11, 1921.)—The elementary discharges of very small section mentioned in a previous paper [see preceding Abs.] enables direct measurements of the velocity of transport of electrified particles to be made. The modified apparatus required for this is described. By employing fields of between 1000 and 6000 volts per cm. and currents of air of speeds varying from 5 to 40 m. per sec. it is found that in air at 76 cm. pressure and temperature 15° C. the velocity of the particles for a field of 1 volt per cm. is 1·59 cm. per sec. for positive charges and 1·65 cm. per sec. for negative. The rapidity with which the particles complete their course when the difference of potential is some thousands of volts, enables the arrangement described to be employed as an anemometer giving instantaneous indications. The following experiment is also described. Two rotating discs, mounted upon the same ebonite axis are placed against the external faces of the armatures of a plane condenser arranged to produce the field. One of the discs is coated with resin, while the other has a small hole which acts as the point of departure of the discharge and which passes at each revolution before a small window pierced in the centre of the corresponding fixed armature. Particles are thus periodically caught by the field and carried upon the opposing armature where another window allows them to continue their course to the resin of the second disc. It is then easy to compare their velocity of translation with a known velocity of rotation. This apparatus gives results quite in agreement with those obtained with the current-of-air method; further, by enclosing it under a large air-pump receiver, the nature of the gas and the pressure can be varied systematically. A. E. G.

1812. *Influence on Sparking Potential of Slight Impurities in the Air.* **E. Meyer.** (Ann. d. Physik, 65. 4. pp. 335–368, June 28, 1921.)—The spark potential in well-dried air at low pressure, enclosed in a glass vessel, does not remain constant over any length of time. Alterations of 23–30 volts can easily be observed, and it is mostly found, but not always, that an increase takes place with the time. It would seem that, on standing, the air becomes impure, and the mixing of the impurities with the air has a very great influence on the spark potential. Some observations on this subject have been already published by the author [see Abs. 786 (1919)]. In the present paper an attempt is made to inquire into the nature of the impurity causing the alteration of spark potential. The apparatus used was the same as that previously described; a diagrammatic sketch of that part of the apparatus through which the air has to pass on its way into the tube is given here, and is fully described. The results obtained appear to be of importance in the theory of the spark discharge. The enormous influence (80 volts) which so small a water-vapour concentration ($e = 0\cdot01$ mm. Hg and less) is difficult to reconcile with the Townsend theory of spark potentials. Then, with the minimum potential, the mean number of the collisions of an electron with air molecules in its path from one electrode to the other is only about 13, a number which is independent of the spark length and the nature of the gases. It is therefore highly improbable with the small water-vapour impurities, that an electron on its path generally collides with a water-vapour molecule. Contrary to the theory of Townsend it must be assumed that the nature of the electrodes exercises an influence on the spark potential—an assumption which is contained in the older theory of Thomson and in support of which the author has published some experimental work. The metal of the electrode has a water skin which may be removed *in vacuo.* As a result of the experiments described it is concluded that up to the present no complete, exact spark potentials for air and other gases at diminished pressures are known. Sufficient account has not been taken of the great influence of small traces of water-vapour. Experiments are in progress in which these probable sources of error are avoided, and it is hoped as a result to be able to obtain exact spark potentials in different gases. [See next Abs.] A. E. G.

1813. *Influence of Water-Vapour on Sparking Potential.* **H. Stücklen.** (Ann. d. Physik, 65. 4. pp. 369–377, June 28, 1921.)—E. Meyer has shown [see preceding Abs.] that very slight traces of water-vapour exercise a very great influence on the sparking potential. Meyer concluded that the water skin on the glass of his apparatus is the cause of the increase in humidity. The object of this research is to investigate the nature of the influence of water-vapour on the spark potential. The apparatus used is similar to that employed by Meyer [see Abs. 786 (1919)]. Results here described show that the very slight traces of water-vapour given up by the glass walls of the apparatus are sufficient to alter the spark potential to a measurable degree. Drying the apparatus through well evacuating it with a diffusion pump still leaves sufficient water-vapour in the glass vessel to influence the spark potential. The method of getting rid of this trace of water-vapour by treating the glass with boiling water and the use of P_2O_5 and evacuating for some days is described.

A. E. G.

1814. *Disappearance of Gas in the Electric Discharge.* II. **Research Staff of the General Electric Co., London.** (Phil. Mag. 42. pp. 227–246, Aug., 1921.)—Previous work [Abs. 510 (1921)] has shown that, except in hydrogen, the absorption of gas occurs only if there is a *glow* discharge. If absorption is determined by electrical conditions at all, it is to be expected that it is closely associated with ionisation of the gas absorbed. Some previous experiments might appear inconsistent with this hypothesis. This difficulty is now removed by showing that in a discharge vessel with electrodes whose area is small compared with that of the walls, the walls can act as a third electrode, receiving almost all the positive ions, the charge on which is neutralised by electrons from the kathode. Moreover, in such a vessel, the free path of the electrons may be great compared with the length of the greatest straight line that can be placed in the vessel. *Faraday's law for gaseous reactions.*—It is shown that the conversion of CO to CO_2, which plays a predominant part in the disappearance of CO, is simply related to ionisation. The reaction $2CO = CO_2 + C$ occurs whenever a positive CO ion collides with a neutral CO molecule. Accordingly, in ideal conditions, the absorption of CO and the current flowing to an electrode which receives all the positive ions and no other charged particles, would obey Faraday's law for a " semivalent " ion. But it is only in carefully chosen conditions that any approach to this law can be exhibited experimentally, and the perfect proportionality seems impossible to obtain. The difficulties arise from (i) the reversibility of the reaction; (ii) the recombination of the ions in the gas; (iii) the arrival of positive ions at the kathode, where the current they carry is indistinguishable from that carried by the emergent electrons. The first difficulty may be peculiar to the reaction studied; the second and third arise in all cases, and would seem to make illusory most of the cases of Faraday's law in gases that have been recorded hitherto.

Similar preliminary experiments on nitrogen have been made. Here again, absorption is proportional to ionisation, but the reactions involved are much more complex. The "clean-up" of hydrogen, described by Langmuir, seems entirely independent of ionisation. Experiments seem to show that a luminous discharge can be obtained, showing the "many-lined" spectrum of the gas, without any appreciable recombination taking place. This fact may be of importance for the theory of spectra. A. W.

1815. *Velocity of Propagation of Electric Waves in Air and Along Wires.* **K. F. Lindman.** (Finska Vetenskaps-Societetens Förhandlingar, 58. 5. p. 47, 1915–1916. Jahrb. d. drahtl. Tele. 18. pp. 48–49, July, 1921.)—Measurements were made of the wave-length of waves generated by a linear oscillator, first, with a Lecher wire system, and secondly for waves in air reflected from a large copper sheet. The results agreed to within 0·3 %, and the velocity along the wires was within 0·1 % of the velocity of light. The results thus afford verification of Maxwell's theory. A. W.

1816. *Electric Oscillations in Straight Wires and Solenoids.* **J. S. Townsend** and **J. H. Morrell.** (Phil. Mag. 42. pp. 265–278, Aug., 1921.)—It is shown that in the maintained oscillations of an electric circuit the fundamental oscillation is often accompanied by feebler ones of frequencies precisely 2, 3, times that of the fundamental. But these harmonics are not free oscillations which can exist independently. A complete set of these free oscillations was obtained from a solenoid, and it is shown that there is no simple relation between the frequencies of these oscillations. E. H. B.

1817. *Note on Vacuum Tubes Used as Detectors.* **L. Hartshorn** and **E. S. Keeping.** (Phys. Soc., Proc. 33. pp. 249–257; Disc., 257–258, June, 1921.)—Describes the development of a robust form of vacuum tube which was used as a detector in the "wireless" circuits carried by aeroplanes. Platinum electrodes are replaced by strips of tin-foil, to which contact may be made by the spring clips holding the tube in position.

II. It was found that when a discharge is passed through such a tube, the walls are affected in such a way that thenceforth it is much easier to get a discharge to pass. The change produced by the first discharge is annulled by heating the tube above 210° C. Further, if the walls are coated on the inside with a metallic film, this first discharge is unnecessary, and the tube is unaffected by heating, but when the walls are coated with an insulator it is if anything more difficult to pass a discharge. A silica tube behaves like one coated with metal. It seems possible that the change in the tube may be due to the formation of a layer of gas molecules on the walls by the first discharge. The explanation of the behaviour of the silica tube is a difficulty. AUTHORS.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1818. *Resistivity of Selenium; Properties of* Se_1. **H. Pélabon.** (Comptes Rendus, 173. pp. 295–297, Aug. 1, 1921.)—It is possible to measure the resistance of selenium even when that body is in a liquid state, by utilising gold electrodes. The electric conductivity of selenium liquid increases very rapidly when the temperature is raised to about its boiling-point 690°; *e.g.*, at 390° the resistivity in ohms-cm. is 76,650 ohms, at 540° it is 2247 ohms; and at 690°, 88 ohms. When the common logs of the numbers representing the different resistances are plotted as ordinates with the corresponding temperatures as abscissæ, the points lie on a straight line. The resistivity of selenium liquid is given with sufficient accuracy by the equation: $\log \rho = 8 \cdot 506 - 0 \cdot 0095t$, where ρ is the resistivity in ohms, and t the temperature. While cooling, the resistance varies in the inverse sense, the same values being obtained for the various temperatures as during heating. Towards 300° the resistance diminishes suddenly with such velocity that no measurement is possible; it passes a minimum value ρ' towards 300°, increases again slightly when the temperature approaches 260°, passes by a second maximum ρ'' and then finally diminishes slowly until the ordinary temperature is reached. The values ρ' and ρ'' as well as the corresponding temperatures t' and t'' vary from one experiment to another; they appear to depend on the velocity of cooling. By slowly cooling selenium which has been previously melted and its temperature raised to the neighbourhood of boiling-point, a variety of selenium which the author calls S_1, is obtained at the ordinary temperature. It is a grey, grained solid, a conductor of electricity, [specific resistance of the order some hundreds of ohms], and not sensitive to light. Selenium S_1 has not constant properties. If its temperature is raised to a value T higher than ordinary temperature the resistivity takes a new value ρ_1T and when led back to temperature t the resistivity is found to be increased to a value ρ_2t, quite different from ρ_1t. If the operation is repeated with this specimen, similar results are obtained with each heating as is shown by the following table:—

$t = 18$.	$T = 132°$.
$\rho_1(t) = 377$ ohms	$\rho_1(T)$ 304 ohms
$\rho_2(t) = 447$,,	$\rho_2(T)$ 319 ,,
$\rho_3(t) = 486$,,	$\rho_3(T)$ 326 ,,
$\rho_4(t) = 521$,,	$\rho_4(T)$ 332 ,,

It is to be noticed that the numbers $\rho(T)$ show smaller variations than the numbers $\rho(t)$. It results from this that the temperature coefficient of ρ is the higher the greater the initial resistance of the selenium. According to this the action of light on the conductivity of selenium might be explained by the action of heat radiations. According to the observations made by Hesehus, the sensitivity of selenium to light ought to be the greater the higher its resistance. The variation of the temperature coefficient is not sufficient to explain the great sensitivity of certain selenium piles. These piles are generally formed with sheets of copper, a metal very readily attacked by selenium, while on the other hand the piles constructed with sheets of gold are only very slightly sensitive to light. A. E. G.

1819. *Properties of Manganin: Resistivity and Thermoelectromotive Force.* **M. A. Hunter** and **J. W. Bacon.** (Am. Electrochem. Soc., Trans. 36. pp. 323–335; Disc., 335, 1919.)—*Resistivity and Thermoelectromotive Force.*—No definite specifications for the preparation of manganin have been given. It has been understood to be an alloy of Cu, Mn, and Ni with a low temperature coefficient of resistance. The authors have measured the effect of small variations in the percentage of Mn, Ni, and Fe on the resistivity and on the temperature coefficient of the same. The thermoelectric force of the alloy against Cu was also determined between 0° and 50° C. The results are shown in the table.

Peocentage Composition of Sample.				Temp. Coefficient 13°–24° C. Ohms per Ohm Degree.	Resistivity in Microhm-cm. at 20° C.	Thermoelectric Force (Microvolts per 1 deg. C.).
Cu.	Mn.	Ni.	Fe.			
88·02	9·93	1·74	0·24	$1·2 \times 10^{-5}$	$34·2 \times 10^{-6}$	4
87·24	10·26	1·77	0·52	$1·5 \times 10^{-5}$	$37·4 \times 10^{-6}$	5
88·20	8·84	1·78	0·93	$0·33 \times 10^{-5}$	$55·6 \times 10^{-6}$	3
83·60	12·03	3·41	1·04	$0·22 \times 10^{-5}$	$47·8 \times 10^{-6}$	8
84·72	12·83	2·08	0·73	$0·38 \times 10^{-5}$	$50·8 \times 10^{-6}$	4
84·07	12·98	2·60	0·82	$0·57 \times 10^{-5}$	$51·1 \times 10^{-6}$	—

The chemical analysis is that of the prepared specimen. The amount of Mn is always less than that added, owing to oxidation. In the first two samples Fe was not added; its presence is due to its existence as an impurity in the Mn. The samples were annealed at 700° C. in a stream of CO_2 for a few minutes and afterwards placed for 5 hours in an oil-bath maintained at 150° C. The authors conclude that small variations in the Mn content affect the resistivity but not the temperature coefficient. The latter is affected by the presence of Fe, about 1% giving the least value for this coefficient. L. L.

1820. *Increase of the Dielectric Constant of a Zinc Phosphor by Light.* **W. Molthan.** (Zeits. f. Physik, 4. 2. pp. 262–266, 1921.)—The increase in the dielectric constant of cupriferous Sidot blende under the action of light, observed by Gudden and Pohl [Abs. 85 (1921)], is found to rise in extent with diminution in the frequency of the alternating field used for the measurement. From the nature of the relationship between the increase mentioned and this frequency a first approximation is obtained to the order of magnitude of the molecular complexes within which the electrons move; the result represents about ten times the diameter of a molecule, this being in good agreement with Lenard's representation of the dimensions of the phosphorescence centres. **Errata** (Ibid. 5. 4. p. 284, 1921). T. H. P.

1821. *Change of the Electric Resistance of Carbon with Gas Absorption.* **K. Siebel.** (Zeits. f. Physik, 4. 2. pp. 288–299, 1921.)—A carbon filament, 9 cm. long, 0·7 mm. in diam., is mounted in a glass vessel, joined to a Gaede mercury pump, and connected with a bridge and a moving-coil galvanometer. The resistance of the filament in air at 76 mm. was, at 0°, 29·5106 ohms and sank to 29·4791 ohms at a pressure of 0 mm. When the vessel was exhausted while the filament was raised to a bright red glow, the resistance fell to 27·7 at 16·6° and 0 mm. On readmitting the air the resistance rose at once from 27·6446 to 27·8892 and continued to rise very slowly to 29 ohms in 11 days. Similar experiments were made in atmospheres of NH_3 and also of SO_2 and CO_2, in which the gas-absorption effects are stronger than in air, decreasing in that order; ammonia is much more readily absorbed by carbon than air, and the resistance increase in ammonia was, in 1 day, 3 times stronger than in air. The temperature coefficient of the resistance is also greater in ammonia. The limit value of the resistance is greater at higher gas pressure than at lower pressure; the temperature coefficient decreases when the filament is heated repeatedly. Reference is made to Peczalski [Abs. 867 (1918)]. H. B.

1822. *Distributed Capacity of Inductance Coils.* **G. Breit.** (Phys. Rev. 17. pp. 649–677, June, 1921.)—*Effective Capacity of a Coil Defined.*—Experiments show that if a coil is connected in series with a condenser of capacity C, the frequency ($\omega/2\pi$) with which this combination is in resonance is given by $L/(C + C_0) = 1/\omega^2$, where L and C_0 are constants. The constant C_0 is called the *effective capacity* of the coil, sometimes simply "the capacity" of the coil. A general formula, equation (6) in the original, is derived for its calculation.

Single-layer Solenoid.—The formula is applied to the short single-layer solenoid, used when grounded in an elliptical shield and when insulated from the shield, and to the short single-layer solenoid used when grounded and insulated in free space. An explanation is given of the remarkable *constancy of* C_0 as found by experiment in the case of short coils. *Experimental Verification.*—An experimental verification is given by direct measurement of capacity and inductance. The current distribution in a coil has also been studied experimentally. The results have verified the theory. AUTHOR.

1823. *Detecting Properties of Galena.* **(Mlle.) P. Collet.** (Ann. de Physique, 15. pp. 265–361, May–June, 1921.)—This paper gives a more detailed description of work previously dealt with. [See Abs. 1197 and 1198 (1920).] A. W.

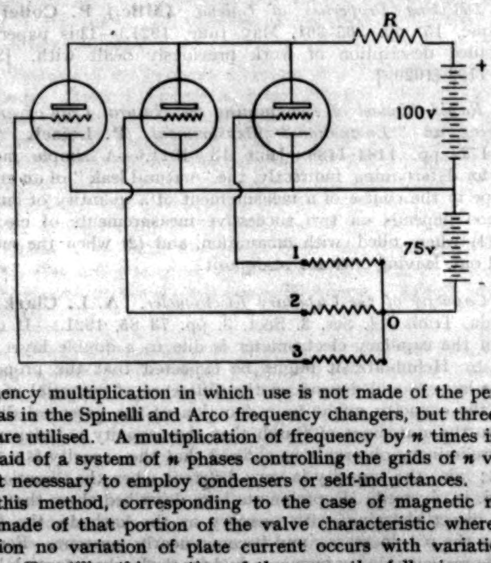
1824. *Rapid Method of Determining the Natural Leak of an Electroscope during an "Emanation" Measurement.* **P. Loisel.** (Comptes Rendus, 172. pp. 1484–1486, June 13, 1921.)—A simple method is described for determining, indirectly, the "natural leak" of an emanation electroscope in the course of a measurement of a quantity of emanation. The method depends on two successive measurements of electroscope current—(1) when filled with emanation, and (2) when the emanation is pumped out, leaving only active deposit. A. B. W.

1825. *Capacity of the Capillary Electrometer.* **A. L. Clark.** (Roy. Soc. Canada, Trans. 14. Ser. 3. Sect. 3. pp. 73–85, 1921.)—If the large capacity of the capillary electrometer is due to a double layer such as conceived by Helmholtz, it might be expected that the properties of this double layer would depend on the difference of potential of the two sides and the capacity might be a function of the potential difference. Contrary to the statement of Burch that the capacity is independent of the p.d., preliminary observations showed that the capacity is a function of the p.d.; also the capacity is very different when the direction of the applied p.d. is reversed. Experiments here described show that in most cases, for direct charging, with mercury as the kathode, the capacity decreases as the p.d. increases, and becomes nearly constant. For reverse charging the capacity always increases, and for the larger potentials becomes very large. The slope of the curve is continuous through the origin.

Extent of the double layer.—The capacity increases as the meniscus is operated nearer the end of the tube, which is contrary to what might be expected. This suggests that the double layer is not confined to the meniscus, and experiments showed that this is the case, as the acid creeps between the mercury and the glass, and the wetted area is many thousand times the area of the meniscus. A. W.

1826. *Shimizu-Wilson Cloud-Condensation Apparatus.* (Electrician, 86. p. 720, June 10, 1921.)—A brief illustrated description is given of a modification of the cloud-condensation apparatus which C. T. R. Wilson first exhibited in April 1911. T. Shimizu has rendered the Wilson expansion apparatus practically automatic, making it possible to observe continuously the emission of α-, β-, γ-, or X-ray tracks. The apparatus, the same in principle as the Wilson apparatus, has a motor-driven reciprocating action which produces expansions (with corresponding condensations on ion tracks) at the rate of 50 to 200 per minute. Arrangements are made whereby the tracks can be observed visually or can be photographed. In the latter case, an automatic exposure arrangement makes it possible to take a photograph at every expansion in the condensation chamber. Stereoscopic pictures have in this way been taken on kinematograph films—the three-dimensional effect thus obtained making the tracks more valuable on interpretation. A. B. W.

1827. *New Static Frequency-Multiplier.* **P. Mauv** and **V. Bontron.** (Rev. Gén. d'Él. 9. pp. 523–527, April 16, 1921.)—Describes a new method of frequency multiplication in which use is not made of the permeability of iron as in the Spinelli and Arco frequency changers, but three-electrode valves are utilised. A multiplication of frequency by *n* times is obtained by the aid of a system of *n* phases controlling the grids of *n* valves, and it is not necessary to employ condensers or self-inductances.



In this method, corresponding to the case of magnetic multipliers, use is made of that portion of the valve characteristic where owing to saturation no variation of plate current occurs with variation of grid voltage. To utilise this portion of the curve the following arrangement of valves is employed. In the Fig., O, 1, 2, 3 are the three phases of a star connection which give rise to a tripled frequency in the circuit containing the resistance R. Alternative schemes of connection for multiplication are also given, together with details of experiments undertaken in 1918, for the French Government on this subject with a triple changer, Lissajous' figures for which, obtained by means of a Braun tube, are illustrated. B. J. L.

ALTERNATING CURRENTS AND MAGNETISM.

1828. *Magnetic Properties at Low Temperatures of Alloys of Iron with Nickel and Manganese.* **K. Onnes, R. A. Hadfield,** and **H. R. Woltjer.** (Roy. Soc., Proc. 99. pp. 174–196, June 1, 1921.)—The magnetic proportions of a series of manganese-iron, manganese-nickel-iron and nickel-iron alloys have been measured before, during and after immersion in liquid hydrogen, and before and after immersion in liquid helium. Special apparatus, designed for carrying out these tests, is described. The Fe-Mn alloys containing more than about 15 % Mn cannot be made magnetic at atmospheric temperature by immersion in liquid hydrogen or helium, neither are they magnetic at the temperature of liquid hydrogen. The existence of one magnetic, and one non-magnetic, Mn-Fe compound is invoked to explain the phenomena observed, the formulæ $Fe_{12}Mn$ and Fe_5Mn being tentatively suggested for these compounds. With regard to the Fe-Ni alloys, the results obtained were in accordance with the work of other authors. J. L. H.

1829. *Theory of Ferro- and Paramagnetism.* **O. E. Frivold.** (Ann. d. Physik, 65. 1. pp. 1–35, May 13, 1921.)—Langevin's statistical theory of magnetism ignores intermolecular magnetic action. The theory has been extended by Weiss to include ferromagnetic substances by assuming an internal magnetic field due to these mutual actions, in a manner similar to the internal pressure obtaining in van der Waals' equation of state of a fluid. In the present paper the author shows how the magnetisation curves can be obtained by the statistical method when the intermolecular actions are taken into account and thus include in the theory ferromagnetic substances. Two cases are dealt with—(1) a unidimensional problem, the molecular magnets being arranged in a chain; (2) the molecular magnets arranged as a cubic space-lattice. In the first case the calculation is carried out for high and low temperatures. The magnetisation curves near the absolute zero of temperature show a sudden increase for weak fields, which indicates ferromagnetism. As the applied field increases, the curves tend to a maximum, which is characteristic of paramagnetic bodies in the Langevin theory. For higher temperatures the resulting curves are very similar to those of Langevin. The molecular quantity equivalent to "N" in the Weiss theory is also a function of the temperature. For the cubical space-lattice the theory is only developed for high temperatures and the modification of the magnetisation curves is less than in the unidimensional case. The presence of an electric doublet is postulated in addition to the elementary magnet in the atom of the space-lattice. It is established that the term expressing the intermolecular action would be significantly greater with this assumption. L. L.

1830. *Relation Between Anomalous Dilatation and Thermal Variation of Magnetisation in Ferromagnetic Substances.* **P. Chevenard.** (Comptes Rendus, 172. pp. 1655–1657, June, 27, 1921.)—In a former note [Abs. 1167 (1921)] the author formulated the hypothesis that the dilatation of any ferromagnetic substance is made up of two parts, corresponding to the dilatation of the higher and lower allotropes. At a temperature θ the state of the body can be defined by the proportion x of the α form present. In the nickel-iron alloys in the neighbourhood of the compound Fe_2Ni, x is proportional to the square of the magnetic intensity (I^2) when the metal is saturated. At any temperature the specific volumes V, V_α, and V_β of the alloy, and the two component phases α and β, are connected by the equation: $V = xV_\alpha + (1 - x)V_\beta$ or $x = (V - V_\beta/V_\alpha - V_\beta)$. If it is possible to measure the dilatation of α and β, x can be calculated. The normal dilatation curve obtained is that of the higher-temperature allotrope β. The dilatation of α is probably very similar to that of the irreversible Fe-Ni alloys below the allotropic transformation. Plotting the values found for x on these assumptions, a curve is obtained which is almost identical with the variation, with temperature, of the square of the magnetisation when the material is saturated. For iron-nickel alloys containing more than 50 % Ni, errors in the calculation of x become considerable. J. L. H.

1831. *Magnetisation by Rotation.* **R. Gans.** (Univ. de La Plata, Publ. (ser. phys. mat. No. 32.) 2. pp. 137–142, Dec., 1917. Ann. d. Physik, 65. 2. pp. 124–127, May 31, 1921.)—In two papers S. J. Barnett has described the magnetisation of a ferromagnetic cylinder which was produced by a rotation about its axis [see Abs. 1761 (1915), 1167 (1917)]. The present paper contains a criticism of Barnett's theory and replaces one of his formulæ (which yields a value of e/m in accord with the experiments with kathode rays and β-rays) by another which would give for e/m results from 10,000 to 16,000 times smaller. E. H. B.

1832. *Magnetism and Atomic Structure.* **A. E. Oxley.** (Nature, 107. p. 652, July 21, 1921.)—On the cubical atom theory developed by Lewis and Langmuir, it appears that the molecules of CO_2 and N_2O have almost identical electron configurations. A. O. Rankine has shown from viscosity data that each electron system is equivalent to that of 3 adjoining neon atoms in line. The author now draws attention to the fact that the specific susceptibilities of gaseous CO_2 and N_2O are $-0{\cdot}423 \times 10^{-6}$ and $-0{\cdot}429 \times 10^{-6}$ [see T. Soné, Abs. 624 (1920)] and their molecular susceptibilities $-18{\cdot}6 \times 10^{-6}$ and $-18{\cdot}8 \times 10^{-6}$ respectively. The electron systems of the two molecules are apparently identical, but the net positive charges on the atomic nuclei are 8—6—8 for CO_2 and 7—8—7 for N_2O. If, therefore, atomic nuclei possess rotations and are a source of magnetic moment, it must be assumed that the redistribution of the positive charges in the manner indicated involves no change of angular momentum. [See also Abs. 938 (1921).] H. H. Ho.

1833. *Magneto-Caloric Effect; Spontaneous Magnetisation.* **P. Weiss.** (J. de Physique et le Radium, 2. pp. 161–182, June, 1921.)—Langevin's law of magnetisation of paramagnetic gases and solutions is given by: $\sigma/\sigma_0 = \coth a - 1/a$ . . . (1), where σ is the magnetic moment per unit of mass, σ_0 the saturation value of this moment, and $a = \sigma_0 H/RT$. In the interior of a magnetic substance, the ensemble action of the molecules on one of their number gives rise to a molecular field H_m such that $H_m = n\sigma$ . . . (2), where n is a constant. The magnetisation-field intensity graphs given by (1) and (2) intersect at A (Fig. 1), a point which represents a stable state into which the material spontaneously changes. The value of σ indicated by A is called the spontaneous magnetisation. The observed magnetisation cannot go beyond the saturation value for a given temperature, and this is not the absolute or Langevinian saturation σ_0, but differs from it in respect of thermal agitation. For a given temperature, the spontaneous magnetisation is approximately equal to the saturation value, and by using the above equations it may be shown that its value diminishes with rise of temperature to become zero at the Curie point θ. This has been verified for magnetite (Fig. 2), the observed points for which are given as + + + . . . If, for the region above the Curie point, the reciprocal of the magnetisation coefficient is plotted against the absolute temperature, theory gives a straight line through the Curie point. This is verified in the case of ferromagnetic bodies up to a certain stage; it holds for ferro-nickel but not for Fe, Ni, or Co. Above the Curie point, the upper part of the graph is composed of a straight line which cuts the temperature axis beyond the Curie point.

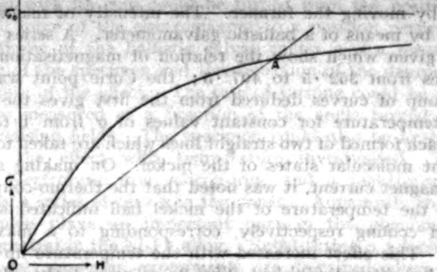


FIG. 1.

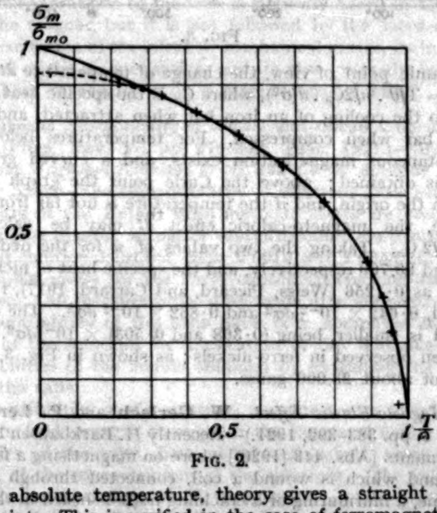


FIG. 2.

On account of these contradictions, further work was undertaken with nickel. A very large electromagnet was used with windings of copper tube to carry the electric and water currents. An aperture in the pole-pieces held an electric furnace in which was placed a sphere of pure Ni. Between the poles and round the furnace were two coaxial coils, wound in opposite directions, and the Ni ball could be placed in the centre of either coil by moving the furnace. The intensity of magnetisation was determined by means of a ballistic galvanometer. A series of isothermal curves are given which show the relation of magnetisation to field, for temperatures from 352°·5 to 407°·5; the Curie point was at 356°·5. Another group of curves deduced from the first gives the variation of field with temperature for constant values of σ from 1 to 12. These curves are each formed of two straight lines which are taken to characterise two different molecular states of the nickel. On making and breaking the electromagnet current, it was noted that the thermo-couple employed to measure the temperature of the nickel ball indicated a momentary heating and cooling respectively, corresponding to a max. change of 0·7 deg. C. This effect increased with the temperature up to the Curie point and thereafter diminished (Fig. 3). Treating the effect from the thermodynamic point of view, the change of temperature dt is calculated to be: $dt = T/\theta \,.\, n/2C_\sigma \,.\, d(\sigma^2)$, where C_σ is the specific heat. This effect is related to the cooling of an iron bar when attracted, and the heating of such a bar when compressed. For temperatures below the Curie point, spontaneous magnetisation exists, and a curved graph through the origin is obtained; above the Curie point the graph is a straight line through the origin, and if the temperature is not far from the critical temperature, the magneto-caloric effect dt may be calculated from $dt = nd(\sigma^2)/2\,C_\sigma$. Taking the two values of n for the deduced graphs as 67,600 and 90,700 respectively, and the specific heat of nickel above the Curie point as 0·1256 (Weiss, Piccard, and Carrard, 1917), two values of dt are found, $0{\cdot}642 \times 10^{-2}\, d\sigma^2$ and $0{\cdot}862 \times 10^{-2}\, d\sigma^2$. The experimental value found is smaller, being $(0{\cdot}368 \text{ and } 0{\cdot}503) \times 10^{-2} d\sigma^2$. The effect has also been observed in ferro-nickels; as shown in Fig. 3, the effect is for a field of about 23,000 gauss. G. E. A.

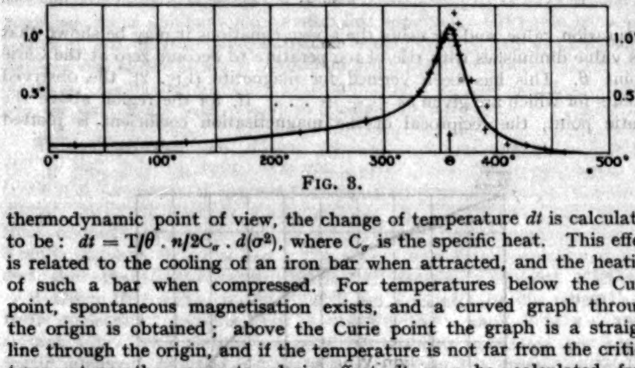


FIG. 3.

1834. *Magneto-Elastic Effect.* **W. Gerlach** and **P. Lertes.** (Zeits. f. Physik, 4. 3. pp. 383–392, 1921.)—Recently H. Barkhausen has described some experiments [Abs. 443 (1920)] where on magnetising a ferromagnetic material round which is wound a coil, connected through an amplifier to a telephone, a murmuring or a crackling noise is heard in the telephone. Barkhausen ascribes this noise to the breaking-up and formation of new groupings of the molecular magnets. The authors have carried out a number of experiments of a quantitative character to elucidate the origin of this phenomenon. A coil placed axially between the poles of an electromagnet has its ends joined to a two-way switch, so that it can be connected either with a ballistic galvanometer, or through an amplifier and rectifying crystal contact with a damped galvanometer. The ferromagnetic material, usually in the form of a wire, 3 or 4 cm. long and a few tenths of a mm. in diameter, is placed axially at the centre of the coil. This coil with its core could be turned from the position parallel to the lines of force of the electromagnet to a position perpendicular to them. The throw of the ballistic galvanometer was a measure of the magnetisation of the specimen and the deflection of the damped galvanometer a measure of the effect. The rate of turning could be varied, and the effect also measured as a function of the angle turned through in various magnetising fields. The specimen could also be heated and the alteration of the effect with temperature investigated. The results obtained for electrolytic iron, silicon-iron, and a nickel-iron alloy are represented by a series of curves in the paper. Apparently the coercivity of the specimen plays an important part in the phenomenon. The "effect" is greatest in the Ni-Fe alloy. Substituting a telephone for the rectifier and galvanometer, experiments are described where the phenomenon is excited by mechanical means. The behaviour of a long wire stretched along the axis of the coil differs from that of a short specimen. When longitudinal vibrations are excited mechanically in the long wire and the note has become almost inaudible, if the electromagnet be excited, the same note is heard immediately in the telephone, but it is followed by a succession of higher but pure tones. If a long wire of non-magnetic material be substituted, the pure tone corresponding to the longitudinal vibrations of the wire is similarly heard in the telephone on exciting the magnet, but it is not followed by the succeeding higher tones. The excitation of the effect by mechanical means, its independence of the reversal of the magnetisation, and its absence in the case of filings lead the authors to regard it as a magneto-elastic effect. L. L.

1835. *Magnetic Susceptibility of Nickel and Cobalt Chloride Solutions.* **L. Brant.** (Phys. Rev. 17. pp. 678–699, June, 1921.)—*Magnetic Susceptibilities and Magneton Numbers of Ni and Co in Aqueous Solutions of their Chloride Salts.*—The susceptibilities of solutions have been found by a modified form of the Kelvin-Wills method. Data are given for nickel chloride solutions ranging in molar concentration from 0·001000 to 3·765 and for cobalt chloride solutions from 0·001018 to 2·0353, for field ranges of 3000 to 14,000 gauss for the lower concentrations and 3000 to 10,000 for the higher. All measurements were made at a temperature of 20° C.

The susceptibilities of the salts have been computed from the susceptibilities of the solutions by application of the Wiedemann law, and the susceptibilities of the metals obtained by extending the Wiedemann relation to the salts.

The susceptibilities of the solutions measured were found to be independent of the field strength throughout the ranges of field used, and the susceptibilities of the salts, both nickel and cobalt, were found to be independent of the concentrations of the solutions. The value found for the molecular susceptibility of Ni is 0·004423 and of cobalt 0·010362. These values give upon application of Weiss's equation 1·60 and 24·5 magnetons respectively for the Ni and Co atoms.

Susceptibility of Air.—An auxiliary result obtained in the experiments is that the volume susceptibility of air at 20° C. and average conditions as regards pressure and moisture extending over a number of months is 0.0288×10^{-6}. AUTHOR.

1836. *Magnetic Properties of the Alkaline-Earth Metals in Combination.* **P. Pascal.** (Comptes Rendus, 173. pp. 144–146, July 18, 1921.)—Taking the value $-7\cdot2 \times 10^{-7}$ for the specific magnetic susceptibility of water, the values of the molecular susceptibilities of salts of the alkaline-earth metals and the atomic susceptibilities of the metals themselves have been calculated. The results confirm the additivity of the diamagnetism of these metals in their normal salts. Exceptions to this rule occur with the chlorides and bromides, for which the diamagnetism is lower than the calculated values, as is usual with several neighbouring halogen atoms capable of exerting supplementary valencies. With certain hydrated salts, there is observed, however, a partial attenuation of the exceptional diamagnetism.

The values found for the atomic susceptibilities of the alkaline-earth metals verify in a striking manner the relation observed previously between the atomic weights (or numbers) and the atomic susceptibilities of the diamagnetic elements of one and the same natural family. Thus, if the logarithms of the susceptibilities are plotted as ordinates and the atomic weights as abscissæ, the points corresponding with calcium, barium, and strontium lie on one straight line and those with calcium, magnesium, and glucinum on another straight line. From the magnetic point of view, radium, which is paramagnetic in combination, occupies a position adjacent to the alkaline-earth metals. T. H. P.

1837. *Determination of "H" by Author's Method and Opposed Field Method.* **W. A. Jenkins.** (Phil. Mag. 41. pp. 454–462, March, 1921.)—The method of a previous paper [Abs. 563 (1914)] depended on the creation of an opposite field twice as strong as H, giving equal periods of swing of a suspended magnet in both fields. A difficulty with the fibre was experienced and two methods are now described in which this difficulty is obviated. In the first of these, the applied field, F, is that of a solenoid placed at right angles to the earth's field. F is found from $4\pi n\mathrm{C}\cos\alpha$, and $\mathrm{H} = \mathrm{F}\cos\theta$, where θ is approximately 45°. To determine θ, mirrors are placed on the sides of an aluminium octagon below the magnet, and the scale zero is observed at the cross-wire of a telescope with the magnet first undeflected and then deflected through 45° by a suitable current. Details of an experiment are given from which $\mathrm{H} = 0\cdot3236$. The sources of error are discussed.

In the second method, the principle is that of the opposed fields. The solenoid is placed parallel to the earth's field, and an external magnet in the Gauss B position causes a deflection of 45°. The solenoid field is then applied so as to cause a total deflection of 135°; H is then found from $2\mathrm{H} = 4\pi n\mathrm{C}\cos\alpha$, the value obtained being $0\cdot3245$, the station being in Dacca, India. G. E. A.

1838. *Testing of Magnetic Compasses.* **R. L. Sanford.** (Bureau of Standards, Bull. 16. pp. 273–279 [Sci. Papers No. 382], 1920.)—Describes the methods employed at the Bureau of Standards.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1839. *Protection of Persons in the Neighbourhood against X-Rays.* **G. Contremoulins.** (Comptes Rendus, 172. pp. 1097–1098, May 2, 1921.)—Describes further researches on the danger of X-radiations affecting persons in the neighbourhood of the installations. Experiments are described in which measurements were made regarding the emission through a stone and brick wall of 50 cm. thickness at a distance of 15 m. from a Coolidge tube. With a 17-cm. spark and 2 millamps. current after 4 hours, an apparent impression was obtained on a plate covered by black paper. In a second experiment plates were affected after 1 hour via human bones and metallic objects at 40 m., and in a third experiment after 4 hours via a dried skull, a partly emptied crab, a glass bottle containing 30 % copper sulphate solution, 3 mm. of lead and a radiochromometer at a distance of 80 m. from the focus. The author concludes that the effect of X-rays cannot be neglected at a distance and that their density falls off proportionally as the square of the distance. B. J. L.

1840. *Regarding the Danger of X-Ray Installations.* **M. Menard** and **Pestel.** (Comptes Rendus, 172. pp. 1178–1179, May 9, 1921.)—Describes experiments analogous to those dealt with in the preceding Abs. by another observer. The present authors' view is that with an oil-immersed tube in a lead container of 6 mm. thickness, for given wave-lengths used for deep therapy with 200,000 volts and 40 cm. spark length, the radiation is only $\frac{36}{1,000,000}$ of its initial intensity and is negligible. Where the patient does not absorb all the radiation, protection can be obtained by the interposition of a lead plate. B. J. L.

1841. *New Form of Stereo-Fluoroscope.* **A. M. Tyndall** and **E. G. Hill.** (Röntgen Soc., J. 17. pp. 122–125, July, 1921.)—The application of the stereoscope to the examination of X-ray plates is useful; two plates have, however, been necessary to secure this effect. The need of an instrument has arisen which would allow the effect to be obtained with only one screen during examination of the patient. This can be secured by a rapid alternation of two positions of the X-ray focus. One method of obtaining the stereoscopic effect is due to Lievre; it requires, however, two tubes or a special tube with two antikathodes excited by means of a rotating commutator. The objection is the high cost of two Coolidge tubes or of the special tube. The authors have devised a method in which a single tube is mounted on an insulated carriage provided with facilities for rapid oscillation in any horizontal line joining the electrodes. By means of a disc rotating in front of the eye at such a rate that the frequency of rotation is the same as the frequency of oscillation of the tube it is arranged that the right eye perceives the tube when it is at the end of the left extremity of its oscillation and the left eye perceives it when at its extreme right displacement; these two images are combined if the rate is sufficient to give a stereoscopic impression. The method thus obviates difficulties in intercepting and starting the discharges entailed by the two-tube method. Diagrams are given and described showing the mechanical devices utilised in order to obtain this result. B. J. L.

1842. *Intensifying Screens in Radiography; Measurement of their Intensification; Simultaneous Employment of Two Screens.* **M. de Laroquette.** (Arch. d'El. Médicale, 29. pp. 201–205, July, 1921.)—The advantage of the screen in X-ray work is mentioned, particularly the reduction in exposure, ensuring greater safety to the tissues. The results of some experiments regarding the various possible positions of screen and plate are described, this being of importance since reduction of time of exposure gives longer screen life. The method of measurement was tintometric. Results are given for exposure differences with and without a screen. It is best to place the screen directly in contact with the gelatine of the plate. It is immaterial whether the screen is above or below the plate, but, on chemical grounds, the gelatine should face the X-ray tube, as 90 % of the effect is absorbed by the glass of the plate. The radiation of the screen, however, appears to pass through the glass without any noticeable loss. With films the result is the same, and it is immaterial if the screen is not in contact with the sensitive side of the film. Gelatino-bromide paper films were found to be four times less sensitive to X-rays than plates, but as they are three times more sensitive to the screen fluorescence the time of exposure is roughly the same.

Unlike the case of glass, paper, being opaque to light, the sensitive side of films must be in contact with the screen surface; the author with a Crookes tube having shown that the impression is eight times less on a film covered with black paper.

The use of two screens, one before and one behind the plate or film, shows the intensification is nearly additive and allows of reduction in exposure time; for example, two screens each of coefficients 8 give a coefficient of 15 when used in this manner. B. J. L.

1843. *Increasing the Efficiency of X-Ray Tubes by Improved Design of Coil and Interrupter.* **M. A. Codd.** (Röntgen Soc., J. 17. pp. 67–74; Disc., 75–78, April, 1921.)—The author points out the present deficiency in the method of measuring X-ray energy by chemical, physiological or electrical means and suggests a practical unit, the radion, defined by $R = M \times t \times 1/d^2 \times G \times 1/50$, where R is number of radions, M the current in milliamps., t the time in seconds, d the distance of object from anode in feet, G the spark-gap in inches, and f is the frequency of interruption per sec. The effects of coil inductance and capacity are then described, the former giving higher current readings but the latter being more productive of X-ray energy. An experiment to prove this is described. For obtaining the best results the impulse ratio of the spark-gap should be high.

New Mercury Interrupter.—The author then proceeds to describe a new mercury interrupter in which not only does the mercury jet revolve in one direction against the segments, but the segments also revolve in the opposite direction, so doubling the number of interruptions and greatly increasing the velocity of break. With this apparatus a frequency of 200 interruptions per sec. is obtainable.

The effect of inductance of the coil primary is next discussed; and since with large coils the time constant is great, the copper segments of the interrupter have to be long compared with the break between them. To obtain full magnetisation we can either increase the applied voltage or reduce the self-induction of the coil. The author adopts the latter alternative and describes and illustrates a coil divided up into two or more units. With such a double-unit coil the centre is earthed or led to a milliammeter rectifier or oscillograph so that there is less danger of the full potential being thrown on one end of the winding by capacity when using a Coolidge control or by accidental earthing of the secondary. Results with such coils are described. B. J. L.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1844. *Classification of Isotopes; Atomic Weights and Nuclear Stability.* **W. D. Harkins.** (Am. Chem. Soc., J. 43. pp. 1038–1060, May, 1921.)—This paper describes "natural" and "experimental" methods of classifying isotopes. The author gives a table showing the relative abundance of the atomic species of the different isotopic numbers, which indicates that the abundance is very high for isotopic number 0, decreases to a minimum in isotopic number 3, rises to a secondary maximum in 4, and again decreases to 5 and 6. "The difference of 4 isotopic numbers between the maxima corresponds to 4 neutrons or a helio group, which is an α-particle plus two electrons, so it indicates that in this range as well as in the radio-active region the α-particle is an important unit in atom building."

The general theory indicates that the number of isotopes per atomic number reaches a maximum somewhere in this region between atomic numbers 28 and 83, and that there are fewer isotopes in the radio-active region, and very many less in the region between atomic numbers 1 and 27.

A rational system for the *nomenclature* of the radio-active atomic species is proposed. A. B. W.

1845. *Separation of Isotopes of Chlorine.* **J. N. Brönsted** and **G. Hevesy.** (Nature, 107. p. 619, July 14, 1921.)—By a method previously described [see Abs. 1658 (1920)] and used for the partial separation of isotopes of Hg, the authors claim to have succeeded in partially separating the isotopes of chlorine. When about half of a strong solution of hydrochloric acid cooled down to about − 50° C. was evaporated in a high vacuum, the mixture of water and hydrogen chloride being condensed on a surface cooled with liquid air, the condensed part of the HCl was found richer, and the remaining part poorer, as regards the lighter constituent of chlorine than the ordinary HCl. The effect was enhanced by repeated separations in the above manner, and the different portions were examined by two different methods—(*a*) density determination, and (*b*) precipitation with silver nitrate. The results by these two methods were in close agreement. A. B. W.

1846. *Mechanism of Chemical Actions Produced by X-Rays.* **A. Dauvillier.** (Comptes Rendus, 171. pp. 627–629, Oct. 4, 1920.)—The experiments of C. T. R. Wilson indicate that the effects produced on matter by the absorption of X-rays are solely due to the corpuscular radiation which results from it. The author now attempts to show, on this basis, how a single type of reaction will explain chemical actions which constitute one of the effects of the X-radiation. It is at once noticeable that the only mineral substances chemically sensitive to the action of X-rays are those for which Langmuir, Born and Landé, Debye and Scherrer, have suggested or proved the existence of an ionic structure. All other sensitive substances—colloids, electrolytes, glasses, etc.—similarly contain ions. From this it seems that the cause of the chemical actions depends on the destruction of the negative ions. The slow corpuscles expelled neutralise the neighbouring positive ions, and the electro-positive and electro-negative elements are thus liberated in the atomic state. This accounts for the colour effects observed in solid or "glassy" substances (crystals and glass) and the chemical modifications in mobile media (electrolytes).

The author considers a number of such chemical reactions in detail and explains the observed effects on the basis of the above theory.
A. B. W.

1847. *Photographic Method for Recording Chemical Reactions which are Accompanied by Pressure Variations.* **P. Jolibois.** (Comptes Rendus, 172. pp. 809–811, March 29, 1921.)—The double galvanometer of le Chatelier and Saladin has been adapted for the photographic recording of the critical points of metallic alloys. This is attained by directing respectively to each of the galvanometers which constitute the apparatus: (1) a current proportional to the difference between the temperature of the specimen and that of a body which does not undergo transformations within the interval investigated. The author has now sought to extend the use of this instrument, and to adapt it to the study of chemical reactions which evolve gases and so exhibit pressure variations. The experimental arrangements for attaining this object of relating temperature and pressure are described in detail with an illustrative diagram. It is claimed that the apparatus can record in a single operation the vapour tension of a body and the dissociation tension of a compound. A comparison of reaction velocities under given thermal conditions may thus be made, also the temperatures at which reactions attain appreciable velocities; *e.g.*, the temperatures of reduction by hydrogen, CO, etc. The author points out how his results may be generalised, *i.e.*, how the electrical conductivity of electrolytes and of alloys may be recorded as a function of other magnitudes. H. H. Ho.

1848. *The Principles of some New Methods for the Determination of Molecular Weight.* **C. Matignon.** (Comptes Rendus, 172. pp. 1036–1038, April 25, 1921.)—An examination of various methods in use for the determination of molecular weight—*e.g.*, cryoscopic, tonometric, solubility, etc.—has evolved the following general characteristics:—If in a two-phase system in physical equilibrium, the latter be modified by dissolving the substance under investigation in one liquid phase of the system, the same body not occurring in the other phase, then the variation of the factor which determines the state of equilibrium is related to the molecular concentration of the dissolved substance. In cryoscopy, for example, there is equilibrium under atmospheric pressure between the liquid phase constituting the solvent and the solid phase formed by the same body; the equilibrium factor is the temperature, and the solute should be insoluble in the solid phase. This expression of different methods by a common formula immediately suggests generalisations in both physical and chemical equilibria; and in the present paper the author draws attention to the utilisation of chemical equilibrium for the determination of molecular weights.

If a liquid substance A dissociates into a gas B and a solid C, and C be insoluble in A, then: $A_{liq} \rightleftarrows B_{gas} \times C$, where A, B, C represent molecules. If p_a, p_b, p_c are the pressures of A, B, and C in the vapour phase, then, applying the law of mass action to the system in equilibrium at a given temperature: $p_a/p_b \times p_c =$ const. In A let a weight U of a substance be dissolved which is without chemical action on B and C, then p_a will decreased by a quantity a, p_c will be unchanged, and in order that the equilibrium law may be applied the tension p_a must be diminished by a value x such that: $p_a/p_b \times p_c = (p_a{}^{-a})/(p_b{}^{-x})p_c$, from which $x/a = p_b/p_a$. Now a is related to the molecular weight M of U by $a = K\pi/M$, where π is the weight of U in 100 gm. of solvent and K is a constant dependent only on the nature of A, therefore $x = K \,.\, p_b/p_a \,.\, \pi/M = K'\pi/M$, where K′ is a new constant This is the classical formula used in actual physical methods. Other systems lead to the same formula, which is therefore general. The method may also be applied to divariant systems. By this method the molecular weight of one solid dissolved in another is capable of determination.

H. H. Ho.

1849. *Oxidation of Carbon Monoxide by Passage with Oxygen or Air through the Silent Discharge and over Catalysts.* **A. B. Ray** and **F. O. Anderegg.** (Am. Chem. Soc., J. 43. pp. 967–978, May, 1921.)—This research was primarily conducted with a view of devising a method for removing the toxic gas, carbon monoxide, from air. Mixtures of carefully purified CO and air or oxygen were circulated through an ozoniser either of the Berthelot type operated with an induction coil giving 10,000 volts, or an apparatus with Al electrodes working with a potential of 58,000 volts and giving a large corona discharge. Partial oxidation of the CO to CO_2 resulted, together with the formation of ozone. The amount of oxidation was found to be determined by the nature of the gas, the rate of passage through the silent discharge, the electrical conditions, and the catalytic decomposing action of substances in contact with the ozone formed. Decreasing the rate of passage tended to reduce the yield of ozone and increase the amount of oxidation, which would indicate that the oxidation results from the ozone at first formed or from some other active modification of oxygen or CO. Mixtures of ozonised oxygen and CO alone were found not to react; in presence of finely-divided silver and other metals, however, the ozone is catalytically decomposed and the CO almost completely oxidised. The most complete decomposition of ozone and most efficient oxidation of the CO was brought about by silvered asbestos. In general, the action was largely affected by the degree of fineness and the past history of the catalyst. In the ozoniser, the oxidation appears to take place partly while the gases are under the influence of the discharge and partly while under the influence of the catalyst. The total oxidation obtained under the influence of the discharge is apparently greater than can be accounted for by the assumption that it is all caused as a result of simple ozone decomposition, thus indicating the formation, under these conditions, of an active modification of CO or of oxygen other than ozone. J. N. P.

1850. *Equilibrium Diagram of the Iron-Silicon System.* **T. Murakami.** (Tôhoku Univ., Sci. Reports, 10. pp. 79–92, June, 1921. 48th Report of the Iron and Steel Research Inst.)—The materials used were a mild steel and a ferro-silicon containing 94·8 % of Si. Addition of silicon to iron lowers the liquidus to 1220° C. at 23 % Si, where liquidus and solidus coincide, giving solid solutions of Fe and compound Fe_3Si_2. Further addition of Si raises the liquidus to the compound FeSi (m.p. 1420° C., Si = 33·6 %). These compositions give primary FeSi + liquid; this solidifies at 1220° C. to a solid solution. At 1020° C.

this solid solution reacts with FeSi, giving solid solution + Fe_3Si_2 for Si below 25 % and FeSi + Fe_3Si_2 for Si above this. Solubility of Fe_3Si_2 in Fe increases from about 17 % at 500° to 23 % at 1020°. A number of photomicrographs are reproduced; the specimens having been etched with aqua regia. J. L. H.

1851. *Influence of Manganese on Malleable Cast Iron.* **E. Leuenberger.** (Stahl u. Eisen, 41. pp. 285–287, March 3, 1921. Chem. and Met. Eng. 24. pp. 751–752, April 27, 1921.—Abstract.)—More than 0·4 % of manganese is considered deleterious for the strength of cast iron, but opinions differ. The author mixed a Swedish charcoal iron with scrap and added Mn (as 50 % ferromanganese) so as to vary the Mn percentage between 0·15 and 1·74. The 12 specimens were prepared in an oil furnace; they contained about 2·9 % C (2·6 to 3·3), 0·4 Si, 0·07 (0·05 to 0·097) P, and 0·04 % S. The test rods of 12 mm. diam. (six of each) were reheated with hammer scale to 980° for 95, 130, or 260 hours. The tensile strength increased with the percentage of Mn, but decreased on prolonged heating. The elongation was not influenced so long as the Mn kept below about 1 %; then the elongation decreased, but the longer the heating the higher the percentage of Mn at which this decrease sets in. Thus higher percentages of Mn than 0·4 seem admissible; but precaution is advisable because such iron inclines to cracking, and good thin-walled castings are difficult to obtain. H. B.

1852. *Alteration of Steel near* 500° *C.* **P. Grenet.** (Soc. Ind. Minérale, Bull. 63. 2. pp. 339–353, 1919. Rev. de Mét. 18 E. pp. 80–82, Feb., 1921.)—The rapidity of cooling following reheating after quenching is not without influence. But it affects only the work done in fracture, not the tensile strength, and the effect is shown only when the rate of cooling is very slow. The author finds that prolonged reheating to 500° C., whether followed by quenching or not, has a deteriorating influence on steels first heated to 650°, making them brittle though not hard. This can be cured by reheating to above 650°. The effect is marked in hard or semi-hard chrome-nickel steel (C 0·2 per cent. about, Cr 0·4 to 1·5, Ni 2 to 4, Mn a little above 0·2); the effect is less marked in soft chrome-nickel steels. The specimens were quenched in oil or water at 850° or less, reheated at temperature up to 862°, and then treated repeatedly in various ways, the cooling taking days or hours. Some weak effect is also observed in ordinary steels, this latter effect depending upon the impurities. These steels contained about 0·3 % C, 0·5 to 0·82 Mn, 0·158 to 0·223 Si, 0·062 to 0·170 P, and 0·038 to 0·049 % S; the deterioration is most noticeable in the presence of relatively high percentages of both Mn and P, less so when Mn alone is high, and is not observed in carbon steels not rich in either Mn or P. H. B.

1853. *Hardness of Soft Iron and Copper Compared.* **F. C. Kelley.** (Am. Electrochem. Soc., Trans. 34. pp. 325–328; Disc., 329, 1918.)—Samples of American "ingot iron" and ordinary commercial cold-rolled copper were given similar treatments in an electrically-heated vacuum furnace, and then carefully tested for hardness by the Brinell method. The treatment consisted in annealing for several hours at 770° to 950°, annealing in hydrogen and in a vacuum. Commercial copper ranged from hardness 80, as received, down to 40; ingot iron from 95 down to 60. The dead-soft iron can be whittled with a knife, and may find uses in place of pure soft copper. AUTHOR.

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1854. *Anomalous Thermal Expansion in Hardened Irreversible Nickel-Steels.* **T. Sutoki.** (Tôhoku Univ., Sci. Reports, 10. pp. 93–99, June, 1921. 49th Report from the Iron and Steel Research Inst.)—High-carbon (0·9 %) nickel steels containing from 2 to 30 % of Ni are examined. Dilatometer and magnetic measurements are made during reheating of the quenched material. Two breaks occur in the curves obtained: the lower (130° C.–200° C.) is attributed to the separation of cementite from α martensite and decreases with increasing Ni to 20 %, when it disappears; the second (310–360° C.) is attributed to the separation of cementite from β martensite and occurs in all the alloys examined. Hence it is inferred that α martensite is absent in high Ni steels, the transformation temperature of austenite to β martensite being lowered and that of β martensite to α martensite inhibited. J. L. H.

1855. *The Cause of Quenching Cracks.* **K. Honda, T. Matsushita, and S. Idei.** (Iron and Steel Inst., J. 103. pp. 251–266; Disc., 267–269, 1921. Engineering, 111. pp. 595–597, May 13, 1921.)—It is well known that during the quenching of high-carbon steels in water cracks are often formed on their surfaces; the cause is generally attributed to (1) the difference in martensitic expansion of adjacent parts during quenching, and (2) the non-uniform distribution of temperature in the specimen during quenching. It it pointed out, however, that the sound of cracking is often heard 10 seconds after quenching, and the paper contains the results of an investigation of the phenomena associated with the formation of quenching cracks. It is shown that in a quenched steel a certain amount of austenite is generally present intermingled in martensite, the amount of which increases as the quenching temperature increases. After quenching also there are certain differences in hardness noted, for instance, in small pieces of steel, the periphery is harder than the central portion only when the quenching is very soft. In a moderate quenching the hardness is everywhere nearly equal, but in a hard quenching the periphery is always softer than the interior. This anomalous phenomenon is explained by the presence of the arrested austenite in martensite. The quenching cracks in small pieces of steel occur when the hardness in the central portion is much greater than in the periphery. The cause of the cracking is attributed to the stress caused by the difference in the specific volumes of austenite and martensite: the specific volume of the former structure being much smaller than that of the latter, the central portion exerts a large tangential tension on the periphery, causing thereby the cracking of the specimen. Since the difference in the specific volumes increases as the temperature falls, the cracking usually takes place when the temperature of the quenched specimen approaches room temperature. In a hard quenching the hardness generally increases with the lapse of time, owing to a gradual transformation of the arrested austenite into martensite. In the case of large specimens, cracking may take place in the Ar_1 range, and also in the vicinity of room temperature. The cracking at the high temperature is chiefly caused by the stress due to the structural difference between the inner and outer portions—pearlite and austenite—just below the Ar_1 point; the cracking at room temperature is due to a similar stress, as in the small specimens. C. O. B.

1856. *"Slip-Lines" and Twinning in Electro-deposited Iron.* **W. E. Hughes.** (Iron and Steel Inst., J. 103. pp. 355–363, 1921.

Engineering, 111. p. 583, May 13, 1921. Abstract.)—Describes the microstructure of samples of electro-deposited iron obtained under varying conditions, especially as regards the lines or slip-lines which are found in them. These lines are common to deposits from both the chloride and sulphate solutions; they are formed whether the deposition is conducted at high or low-current density; the temperature of deposition does not appear to effect their appearance, and they are found in deposits of various thicknesses. In baths containing much suspended matter, however, they are not found. These lines are characteristic of overstrained metal, and it is concluded that the deposit must have been the locus of stress. Previously published work is referred to which shows that electro-deposits exercise considerable pressure upon the base metals on which they are formed, this pressure increasing with increases in thickness of metal. It is suggested that the force exerted is one of contraction and is of sufficient magnitude to cause the formation of slip-bands. As regards the formation of twin crystals in deposited metal, this is not definitely settled, although structures resembling twin crystals are described as occurring in electro-deposited iron which had not been annealed. C. O. B.

1857. *The Welding of Steel.* **H. Brearley.** (Iron and Steel Inst., J. 103. pp. 27–43; Disc., 44–62, 1921. Engineering, 111. pp. 551–554, May 6, 1921. Abstract.)—Describes various experiments carried out to study welding of steel, having particular reference to blow-holes and segregates which occur in ingots. Blow-holes are often stated to be completely welded up when the steel is rolled, but the author shows that in many cases this welding is far from perfect, and often gives rise to the so-called "hair lines" found in the finished articles made from the steel.

The strength of welds was examined by drilling a 1-in. hole axially in a 3½-in. billet, forcing a plug into it, and rolling the billet down to a bar 4½ in. by ½ in. Notched bar impact test pieces were then cut from the bar and tested. The better the weld, the lower the impact figure obtained, as the energy required to start a crack is much less than that required to propagate an already started one. By toughening the steel to a suitable amount, it is possible to cause the weld to tear open, and this toughness can be taken as a measure of the quality of the weld. The effect on its welding properties of the presence of sulphur in steel is also discussed, and it is shown that sulphur, as such, does little or no harm, but that it is usually associated with blow-holes which are sources of weakness. Owing to the ease with which the former is detected by means of sulphur printing, its presence may even be an advantage as giving a simple test for the presence of blow-holes. J. L. H.

1858. *Solid Solution of Oxygen in Iron.* **J. E. Stead.** (Iron and Steel Inst., J. 103. pp. 271–276, 1921. Engineering, 111. pp. 627–628, May 20, 1921.)—Describes experimental work on the effect of the cupric etching reagent of le Chatelier and Dupuy (which consists of alcohol [95 %] 100 cm.^{3}, water 10 cm.^{3}, cupric chloride 1 gm., picric acid 0·5 gm., hydrochloric acid 1 to 3 cm.^{3}), on samples of oxidised iron with a view of determining whether oxide of iron can be retained in solid solution in iron. It is shown that when iron is heated in air or oxidising gases the surface layers absorb oxygen which apparently passes into solid solution. When supersaturated, however, the oxide falls out of solution, forming separate globules of free oxide. These globules then become larger and larger as oxidation proceeds, eventually joining together to form continuous layers. Oxidising gases find the most facile passage into the steel between the crystals, and the gradual changes from solid solution to free oxide can be clearly traced along the oxidised junctions. Sulphur, possibly as sulphur dioxide in the gases, penetrates into the body of the crystals, producing sulphide of manganese and, possibly, protoxide of manganese, which appear in globular form. C. O. B.

1859. *Etching Reagents for Copper.* **H. S. Rawdon** and **M. G. Lorentz.** (Bureau of Standards, Bull. 15. pp. 641–668 [Sci. Papers No. 399], 1920.)—Two general types of etching are described, which are designated as " plain " and " contrast." While many reagents as a rule give but one type of etched surface, it is possible to produce either type from some reagents. Generally speaking, contrast etching is best for high, and plain for low, magnifications. Oxidation is of fundamental importance in the etching of copper, and many solutions which normally have but a slight action may be rendered vigorous by passing oxygen through them. As a rule aqueous solutions are best for the etching of copper; in a very limited number of cases, however, alcoholic solutions appear to give better results. Typical etching reagents are described, and photomicrographs are given to illustrate the characteristic features of each. J. L. H.

1860. *Influence of Copper on Rate of Solution of Iron in Acids.* **F. K. Bell** and **W. A. Patrick.** (Am. Chem. Soc., J. 43. pp. 452–465, March, 1921.)—Describes experimental work on the rate of solution of pure iron and alloys of pure iron containing 0·1, 0·3, 0·5, 1·0 and 5 % copper in 28·7 % HCl at 20° C. Pure iron was prepared by the reduction of prepared oxide in hydrogen, and the rate of solution of the prepared alloys was measured by an improved method of measuring the rate of evolution of hydrogen. The rate of solution of the alloys shows a definite decrease in comparison with pure reduced iron as the copper content increases. The rate of solution of pure reduced iron in contact with Pt, Ag and Cu was also determined, and it was found that Pt and Ag show apparently no effect, while Cu greatly lowers the velocity. Experiments with 57 % H_2SO_4 were unsatisfactory, as they were lacking in uniformity, which suggested that the experimental conditions were not under control. Various theories which have been put forward to explain the retarding action of copper upon the rate of solution of iron in acids are examined in the light of the results of the new experiments, and the following new theory is suggested tentatively:—Copper is dissolved in strong acids to a limited extent. This solution of copper is possible because of the formation of complexes with the acid, thereby reducing the copper ion concentration to such an extent that hydrogen ions may be electrically discharged. This dissolved copper, however, in the presence of iron does not remain in solution, but is precipitated out in a finely divided state. This latter state of the copper renders it more readily attacked by the acid and it re-dissolves, so that we have the copper oscillating back and forth between the solution and the iron. The initial amount of the copper dissolved, which depends upon the copper content of the alloy for a given acid concentration, is considered then as being intermittently precipitated in a finely divided state (and therefore more soluble than the copper of the alloy) and re-dissolved, and this layer of precipitated copper which is intermittently present on the surface of the iron retards the solution of the latter. [See Abs. 1168 (1916).] C. O. B.

1861. *Electrically Heated Lehrs for Glass Annealing.* **E. F. Collins.** (Chem. and Met. Eng. 25. p. 119, July 20, 1921.)—Describes the results which can be obtained with electrically heated lehrs, and shows by experimental data that the temperature is very even throughout the furnace. It is possible to obtain automatic control which will enable any desired cooling curve to be accurately followed. J. W. T. W.

1862. *Coefficient of Diffusion of Certain Saturated Solutions.* **B. W. Clack.** (Phys. Soc., Proc. 33. pp. 259–264; Disc., 264–265, June, 1921.)—Gives an account of experiments on the diffusivity of saturated solutions of KCl, NaCl and KNO_3 at constant temperatures near 18° C., when the steady state of diffusion has been attained, employing a method similar to that previously used by the author [Abs. 422 (1917)].

The solution under investigation is maintained at complete saturation by the presence of salt crystals in the diffusion vessel. The theory takes into account the change in volume of this salt as it dissolves, and an expression is obtained for the coefficient of diffusion at complete saturation, which depends on the rate of change in weight of the diffusion vessel with time. The experimental results are found to agree very closely with the values obtained by extrapolation from the results previously found for less concentrated solutions. The author has thus extended the range of concentration over which he has studied diffusion from very dilute solutions right up to complete saturation. AUTHOR.

1863. *Occlusion of Water by Gas-Mask Charcoal.* **B. E. Brown.** (Phys. Rev. 17. pp. 700–706, June, 1921.)—The *variation of amount of water with temperature* was determined between 102° and 140° C. at a pressure of 74 cm. of Hg. About one-third of the water came off between 112° and 114° C. The *variation in pressure* with three of the four concentrations, over the range of temperature from 95° to 130° C., was such as to correspond fairly closely to the variation of pressure for solutions. AUTHOR.

1864. *Graphitic Acid; a Colloidal Oxide of Carbon.* **G. A. Hulett** and **O. A. Nelson.** (Am. Electrochem. Soc., Trans. 37. pp. 103–119, 1920.)—The history of investigations on graphitic acid is given *in extenso,* followed by a record of experiments to determine the vapour pressure of the water from this product at different temperatures. The extensive experimental and chemical work points to the water given off as having been simply absorbed water, and not due to chemically combined hydrogen, while the basic substance is a solid carbon oxide of a colloidal nature in extremely thin plates of approximate formula C_3O or $C_{11}O_4$. AUTHOR.

1865. *Colloid Chemistry and Electrochemistry.* **W. D. Bancroft.** (Am. Electrochem. Soc., Trans. 37. pp. 55–70, 1920.)—A resumé of phenomena which are both colloidal and electrochemical, or cases where one results from the other, such as precipitation of colloids by electrolytes, formation of colloidal solutions by arcs or by electrochemical action or by spraying liquid metal and fusion. Migration of colloidal particles under electrochemical potential, cataphoresis and electrical endosmose, the functioning of a diaphragm, are discussed ; also the effect of colloids on the conductivity of solutions, the action of electrolytes on living tissues, electrostatic precipitation of extremely small particles, electrification of the air and of suspended dust clouds, and metallic fogs or mists in fused electrolytes. AUTHOR.

1866. *Gaseous Hydrides of Polonium, Bismuth, Tin, and Lead.* **F. Paneth.** (Zeits. Elektrochem. 26. pp. 452–454, Nov. 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1921.)—Hydrides may be prepared by various, also radio-active methods [Abs. 267 and 1498 (1920)]. The hydrogen may directly be evolved by the decomposition of water, or by electrolysis (kathodes of S, Se, Te yield the hydrides), or electric discharges may be passed between electrodes of the respective elements through hydrogen or vapour mixtures. Polonium hydride is obtained when polonium electrolytically deposited on platinum acts on ionised hydrogen. The electric methods failed in the case of Bi and Pb, the various kinds of discharge producing merely finely-divided metal which was retained by cotton-wool plugs. By passing in a kind of Wehnelt apparatus the discharge through a fair conductor (sulphuric acid), using a litharge-glycerol cement kathode (instead of compact lead), these hydrides have also been prepared [cf. Deutsch. Chem. Gesell. Ber. 53. pp. 1693–1710 (1920)]. The point is that the direct-current electrolysis is interrupted by bright sparks. The lead hydride is very easily decomposed. Considerations are submitted as to the position in the periodic table, of the elements capable of forming volatile hydrides. H. B.

1867. *Causes of the Forces of Adsorption.* **M. Polányi.** (Zeits. Elektrochem. 26. pp. 370–374, Sept. 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1920.)—Further theoretical considerations [Abs. 560 (1917)], now supported by the calculations of L. Berényi [Zeits. phys. Chem. 94. pp. 628–662 (1920)], and also the data of Titoff. The author's assumptions are that the adsorption potential is independent of the temperature, and, for any particular spot, independent also of the fact whether neighbouring portions of the space are empty or occupied by other molecules ; further that van der Waals' equation of state holds also for the adsorbed condition. Plotting Berényi's values for the adsorption by charcoal of C_2H_4, CO_2, CH_4, CO, O, N, Ar, H, the maximum adsorption potentials of which decrease from 7·1 to 3, he finds that this $\epsilon_{\text{max.}} = k\sqrt{a}$ and that the mutual relation between two molecules depends upon the product $\sqrt{a} \times \sqrt{a_2}$, the *a* being van der Waals' constants, and has no specific character. To account for this he suggests that the attractions are due to a mutual orientation of the electric or magnetic forces ; this orientation cannot be of the nature of a mutual rotation of the molecules, which would be contrary to the author's assumption. When molecules approach one another the adsorbent and adsorbed substance deform one another in such a way that opposite electric or magnetic poles may come nearer. In the case of argon this might be done, in accordance with a suggestion made by Haber in another connection, by the displacement of the two nuclei in the same direction, *e.g.*, from the centre to the right. H. B.

1868. *Solubility.* VI. *Thermodynamical Relation Between Solubility and Internal Pressure.* **J. H. Hildebrand.** (Am. Chem. Soc., J. 43. pp. 500–507, March, 1921.)—From thermodynamical considerations it is shown that only such liquids as have identical values of $(\partial P/\partial T)_v$ are capable of yielding solutions obeying Raoult's law under all conditions, that is, at all temperatures, pressures, and compositions. It is proposed to define internal pressure as $T(\partial P/\partial T)_v$, which is one of the terms of the thermodynamic equation of state, and illustrative values are given for the internal pressures of certain liquids calculated in this way. Since the internal pressure of a solution of non-polar liquids is probably a linear function of the composition expressed in mol-fractions, it is probable that the difference between the internal pressures of the two pure liquids would determine, at least to a considerable extent, the deviation of the solution from Raoult's law. This is essentially the theory of solubility heretofore outlined and supported by abundant experimental data. The criteria previously used for estimating relative values of internal pressure are shown to be in substantial accord with the thermodynamic definition of internal pressure now used, although it is theoretically preferable to use surface energy in place of surface tension [Abs. 270 (1917), 1257 (1919)]. T. H. P.

1869. *Theory of Chemical Reactivity; Calculation of Rates of Reactions and Equilibrium Constants.* **S. Dushman.** (Am. Chem. Soc., J. 43. pp. 397–433, March, 1921.)—A theory of unimolecular reaction velocities is suggested according to which the velocity constant is given by the relation, based on the quantum theory, $k_1 = (Q/Nh)\epsilon^{-Q/RT}$, where Q denotes the heat of activation, N the number of molecules per mol $= 6 \cdot 062 \times 10^{23}$, h the quantum constant, and R has the usual signification. As has been shown by Trautz, the heat of activation may also be calculated from the temperature coefficient of k_1, according to van't Hoff's equation. By combination of this relation with that for Q, it is possible to check the above theory on actual experimental data in the case of the dissociation of phosgene, this being the only uncatalysed unimolecular reaction the velocity constant of which has been measured; the agreement is found to be very satisfactory. Further, as shown by Trautz and others, the velocity constant, k_2, of a bimolecular reaction in gases may be calculated from considerations based on the kinetic theory of gases; this theory is now shown to be in accord with the experimental data in the case of several reactions. Since the equilibrium constant, K, of any reaction is given by the value of k_1/k_2, it should be possible to calculate the free energy from data on the total energy of the reaction, or vice versa; that is, this theory leads to a relationship similar in certain respects to that derived by Nernst on the basis of his heat theorem. When the available data on homogeneous gas reactions are developed, it is found that the values of the heat reaction calculated from equilibrium constants by means of the above theory are, in a large proportion of the cases, in fair agreement with the total heats actually observed. The results show also that the relation suggested for unimolecular reaction velocities may be regarded at present as only approximately true. Such relation is, however, regarded as of fundamental significance, and probably represents an ideal relation which would hold true in all cases if it were not for the interference of other factors at present unknown. T. H. P.

1870. *Comparison of the Atomic Weights of Terrestrial and Meteoric Nickel. I. Reduction of Nickelous Oxide.* **G. P. Baxter** and **L. W. Parsons.** (Am. Chem. Soc., J. 43. pp. 507–518, March, 1921.)—Nickelous oxide prepared by ignition of the nitrate at about 1000° is found to contain 0·11 % of occluded gases. After a correction for the gas content is made, the oxide is found to contain 78·582 % of the metal, the atomic weight of Ni being hence 58·70. For meteoric Ni the same method gives the value 58·68, which is identical with 58·70 within the error of experiment. Richards and Cushman gave 58·68. T. H. P.

1871. *Analysis by Means of Reducing Flames; Detection of Traces of Manganese, etc., in Presence of Iron or Other Substances.* **J. Meunier.** (Comptes Rendus, 172. pp. 678–681, March 14, 1921.)—This method, which permits of the detection of traces of compounds of lead, manganese, calcium, strontium, potassium, lithium, etc., when other methods fail, is based on the principle that, when an oxide or a salt undergoes reduction on introduction into a flame, the latter exhibits a line spectrum of the corresponding metal. The hydrogen flame gives better results than coal gas.

An *apparatus* is described by means of which the powdered material is projected into the tube leading the hydrogen to the orifice where it is burnt. Behind the flame is the slit of a spectrograph. The results obtained with oxalate or oxide of iron are given, the number of lines in the spectrum increasing as the exposure of the photographic plate is lengthened. The presence of a trace of manganese in the iron was readily detected. T. H. P.

1872. *Influence of Salts on Chemical Equilibria in Solutions.* **J. N. Brönsted.** (Chem. Soc. J., Trans. 119. pp. 574–592, May, 1921.)—The theory that all salts are ionised completely in solution but vary in their "activity" is applied (i) to the influence of salts on the solubility in water of other salts, (ii) to the dissociation of water (and other weak electrolytes) which is said to be increased by the presence of salts, *e.g.*, in the ratio 0·68 : 1 in passing from 0·01 to 0·1 *N*, (iii) to the equilibrium in "regulator" mixtures, (iv) to indicator equilibria. Experimental results in accordance with this theory are given. T. M. L.

1873. *Hydration of Electrolytic Ions.* **R. Lorenz.** (Zeits. Elektrochem. 26. pp. 424–431, Oct. 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1920.)—A summary of the views of the author and M. Born. The mobilities of the ions of Li, Na, K, Rb, Cs seem to indicate the smallest radius for the Cs atom and the largest for Li, contrary to theory; the anions Cl′, Br′, I′ migrate too quickly like Cs, and there are other irregularities. Estimates of the radii of moving ions are based upon Stokes' law, and the question arises whether this law is possibly misunderstood. Stokes' law applies to electrically neutral spheres, and will be less reliable as the spheres become smaller and more highly charged. There is a reaction between the charge of the ion and the dipoles of the solvent; the latter will be turned when the ion migrates, and there will be rotational friction in addition to the internal friction of the water. We must hence distinguish between the hydrodynamic mobility of uncharged spheres and the electrodynamic mobility of charged spheres (Born). The hydrodynamic radius of the uncharged sphere is $r^* = r\left\{1 + \frac{1}{3}(r_0/r)^4\right\}$, where r is the true radius and $r_0 = 0 \cdot 833 \cdot 10^{-8}$ cm., theoretically deduced. When the electrodynamic effect predominates, the law of Stokes seems to fail, *i.e.*, the larger spheres travel faster than the smaller. The reversal coincides with the minimum of $r_0^* = 4/3 r_0$. On this view the theory, though incomplete, appears simpler, and it is no longer necessary to distinguish three kinds of space-filling—normal, too small, and too large. In a postscript the author adds that Walden has come to similar conclusions as to non-aqueous solvents, finding that the hydration (or solvation) in non-aqueous solvents will even be greater than in water. H. B.

1874. *Abnormality of Strong Electrolytes.* **D. L. Chapman** and **H. J. George.** (Phil. Mag. 41. pp. 799–801, May, 1921.)—The theory advanced by Ghosh [Abs. 881 (1918), 104, 223 (1919)] to explain the anomalous behaviour of strong electrolytes [see also Partington, Abs. 477 (1920)] involves a large number of assumptions, these including the postulate that the free ions (conducting ions) are those whose kinetic energy is greater than the work to be done in separating them to an infinite distance. It is now shown that, in developing his theory, Ghosh makes a false deduction from this assumption, and that the theory in its present form is not in agreement with the facts if the number of ions whose kinetic energy exceeds a specified value is correctly given by the commonly accepted formula. T. H. P.

1875. *Effect of Amalgamation upon the Single Potential of Aluminium.* **L. Kahlenberg** and **J. A. Montgomery.** (Am. Electrochem. Soc., Trans. 36. pp. 277–288, 1919.)—Measuring the single potential of aluminium in a ½ molar solution of aluminium chloride at room temperature, by means of the calomel electrode, the authors obtained much higher values with amalgamated than with unamalgamated Al, due to the removal of the coat of resistant oxide by the mercury. They showed also that the measurements were actually the single potentials of the Al and not those of an Al amalgam. AUTHORS.

1876. *The Apparent Irreversibility of the Calomel Electrode.* **A. W. Laubengayer.** (J. Phys. Chem. 25. pp. 332–336, April, 1921.)—On electrolysing a solution containing hydrochloric acid and pure calomel with a Pt kathode and mercury anode, polarisation is set up through the formation of a high-resistance film, so that with a potential drop of 6 volts less than 1 milliamp. passes, as against 10 milliamps. for 2 volts with a platinum anode and 10 milliamps. for 2½ volts with a mercury anode and a solution of sulphuric acid and mercurous sulphate. With a mercury kathode in hydrochloric acid, a current of about 0·2 milliamp. can pass before the film forms. When mercurous chloride is present in excess the film forms at a lower current and lower voltage, but appears to have not quite so much resistance. The film appeared to be composed of finely-divided drops of mercury and calomel in a whitish, transparent crystalline form. The experiments show that the apparent irreversibility of the calomel electrode is due to the formation, on the surface of the mercury anode, of a strongly-adsorbed film of mercurous chloride which offers a high resistance to the passage of the current. By removing the film as it is formed, calomel may be prepared electrolytically at a relatively low voltage. J. N. P.

1877. *Electrochemical Effect of Thallium Sulphates; H-O Gas Cells.* **G. Grube** and **A. Hermann.** (Zeits. Elektrochem. 26. pp. 291–297, July 1, 1920.)—To make gas cells more efficient Foerster and Diethelm (1908) used titanous salts as reducing agents on the hydrogen side, and Abegg and Spencer (1905) and Nernst (1912) proposed to add thallium on the oxygen side. The authors oxidise the crystallised thallous sulphate, Tl_2SO_4, electrolytically to $Tl_2(SO_4)_3$, and make potential measurements in sulphuric acid solution varying the current density, acidity, and anode material (Pt smooth or platinised, or PbO_2). The oxidation potential of thallous-thallic solutions in sulphuric acid is found to be $e_h = 1{\cdot}211$ volt; Abegg and Spencer found 1·156, possibly because they disregarded liquid potentials. The potential precludes the hope of accelerating the reactions in gas cells by the aid of these sulphates. The potential of the completely-oxidised thallic sulphate being 1·26 volt, higher than the reversible oxygen potential, this salt is slowly reduced to thallous sulphate again under liberation of oxygen, especially in the presence of platinised platinum and in the light. H. B.

1878. *Effect of an Alternating Current on Hydrogen Overvoltage.* **H. M. Goodwin** and **M. Knobel.** (Am. Electrochem. Soc., Trans. 37. pp. 617–639; Disc., 639–640, 1920.)—A study of the overvoltage of hydrogen on platinum, lead, and copper kathodes when alternating current is superposed on the direct electrolysing current. The apparatus is described, the electrodes, and the manner of working. The effect of varying the alternating current was also studied, the effect of its frequency, and the power factor. The effects seem in general to be due to the oxygen liberated on the kathode by the reverse wave of the alternating current. The magnitude of this depolarisation appears to be independent of the electrodes and of the current density, and determined primarily by the ratio of alternating to direct current used. The effect increases slightly as the frequency decreases, but is practically independent of the power factor. AUTHOR.

1879. *Singular Oscillatory Movements in Mercury Electrodes.* **S. Magrini.** (Accad. Sci. Med. e Nat. Ferrara, pp. 1–4, March 23, 1921.)—When the end of a piece of clean magnesium wire is brought just into contact with a drop of mercury placed in a basin or watch-glass and covered with 0·1–0·2 per cent. hydrochloric acid solution, the mercury at once begins to undergo rhythmic contraction and distension, the movements continuing until the magnesium wire is removed. If the end of the wire is central to the upper part of the drop, the rhythmic movement produces a surface undulated in concentric rings, whereas if a non-central position is occupied by the wire, an undulating ellipsoidal form results, this undergoing rhythmic contraction and distension in directions mostly perpendicular to one another. The rapidity of the oscillations varies with the magnitude of the drop. The same phenomenon is observed if the hydrochloric acid is replaced by potassium hydroxide, sodium carbonate, ammonia, etc., but it seems necessary that hydrogen should be evolved by either direct or secondary chemical action. The phenomenon is especially marked with an Al wire and a solution of potassium cyanide. With an iron wire and hydrochloric acid solution, the movement of the mercury occurs only if the wire is applied to the side of the mercury where the curvature of the drop is greater than at the upper surface.

The cause of the phenomenon seems to lie in electrolytic polarisation and depolarisation, with the consequent variations in the surface tension and form of the mercury drop. The mercury and other metal with the interposed electrolyte constitute a true cell and, even on open circuit, the rhythmic movement of the mercury must be regarded as a transformation of the electrochemical energy of the system into mechanical work; with Mg in hydrochloric acid and with Al in potassium cyanide, corrosion of the metal is apparent. If the mercury is connected metallically with the metal point by means of a circuit containing a telephone, the latter renders evident the rhythmic variations of a current.

The phenomenon may be produced also by making use of an external e.m.f. in place of that proper to the system, mercury-electrolyte-metal point, the mercury being made the negative electrode. The system may, indeed, be regarded as a current interrupter analogous to that of Wehnelt, although less efficacious than the latter owing to the smaller frequency of the interruptions. T. H. P.

1880. *Electrolytic Formation of Alkali Salts of Ferrous and Ferric Oxides.* **G. Grube** and **H. Gmelin.** (Zeits. Elektrochem. 26. pp. 459–471, Nov. 1, 1920. Paper read before the Bunsen Gesell., Halle, April, 1921.) —A continuation of the researches of Abs. 788 (1920). When iron is anodically polarised in 40 % NaOH, after kathodic activation, at low current density, it is dissolved as divalent metal, some sodium salt of H_2FeO_2 being formed. At higher temperature this dissolution is succeeded in a second stage by the formation of hexavalent ferrate; an intermediate tervalent stage was never observed. The formation of sodium ferrite may take place either by anodic oxidation of the alkaline ferrous solution, or by the reduction of ferrate at the platinum kathode; this latter reduction can also be effected by purely chemical methods by means of activated powdered iron at high temperature (Haber). Details of potential measurements are given. H. B.

1881. *Chlorine Overvoltages.* **E. Newbery.** (Chem. Soc. J., Trans. 119. pp. 477–486, April, 1921.)—Measurements were made in the intervals immediately following the interruptions of an electrolysis current of the excess potential between the anode and a surrounding electrolyte of *N*-hydrochloric acid over that given by an electrode surrounded by chlorine in the same electrolyte. Of different materials used as anode, only carbon, rhodium, iridium, and platinum were unattacked, while gold, chromium, palladium, and in some cases, thallium, became passive at definite current densities and then remained unattacked. It is considered that, in general, the electrode surface becomes saturated with gas and, if no compound is formed, the overvoltage is zero.

By comparing with the results of earlier work on hydrogen and oxygen overvoltages, it is concluded that the overvoltage is the same whatever gas is liberated whether carrying a positive or negative charge, and with different elements is merely determined by the valency of the element. J. N. P.